WORLD OIL

DRILLING PROGRESS ISSUE

Here are 38 pages of industry's latest developments and technological advances

See Pages 135-172

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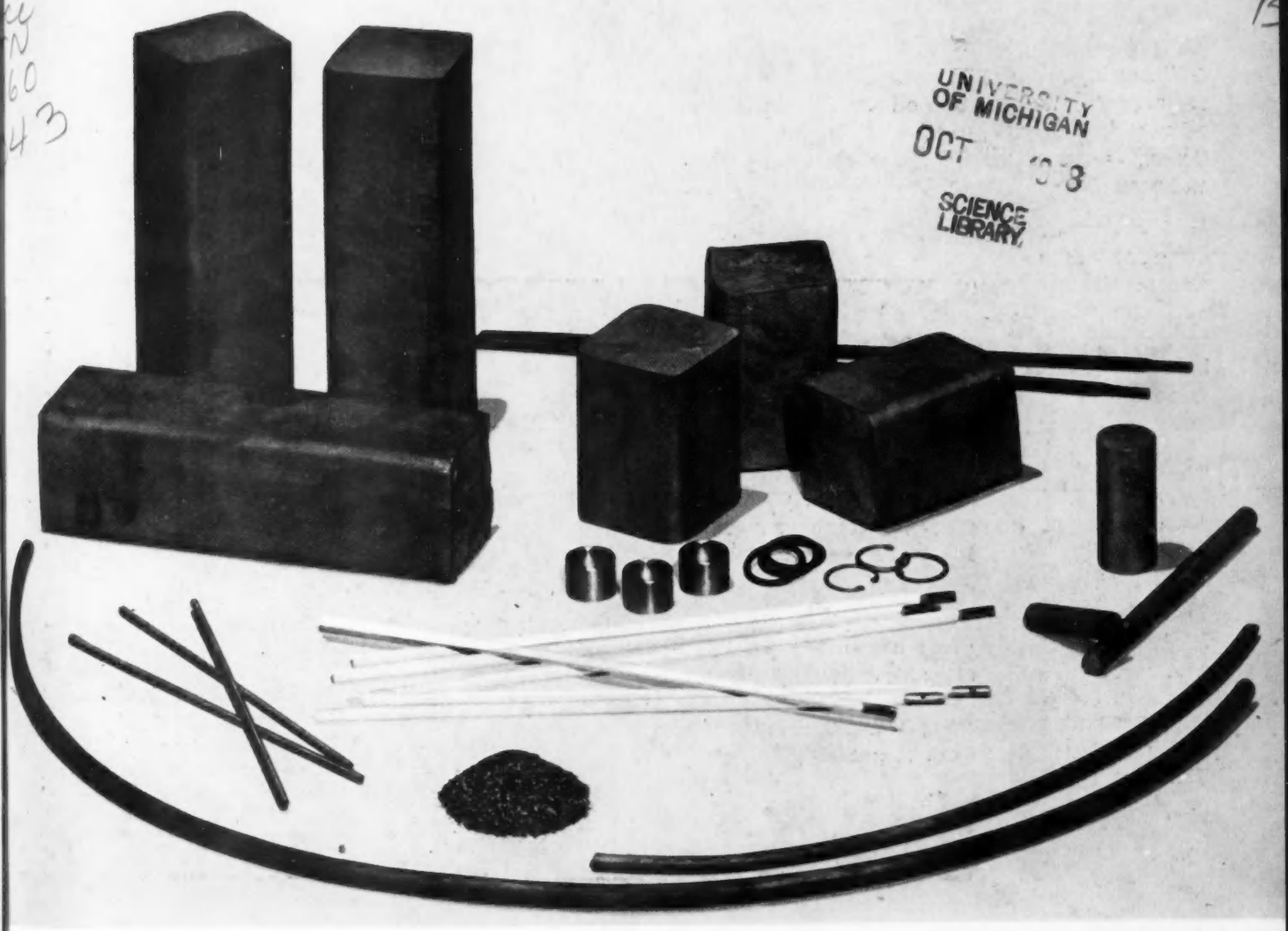

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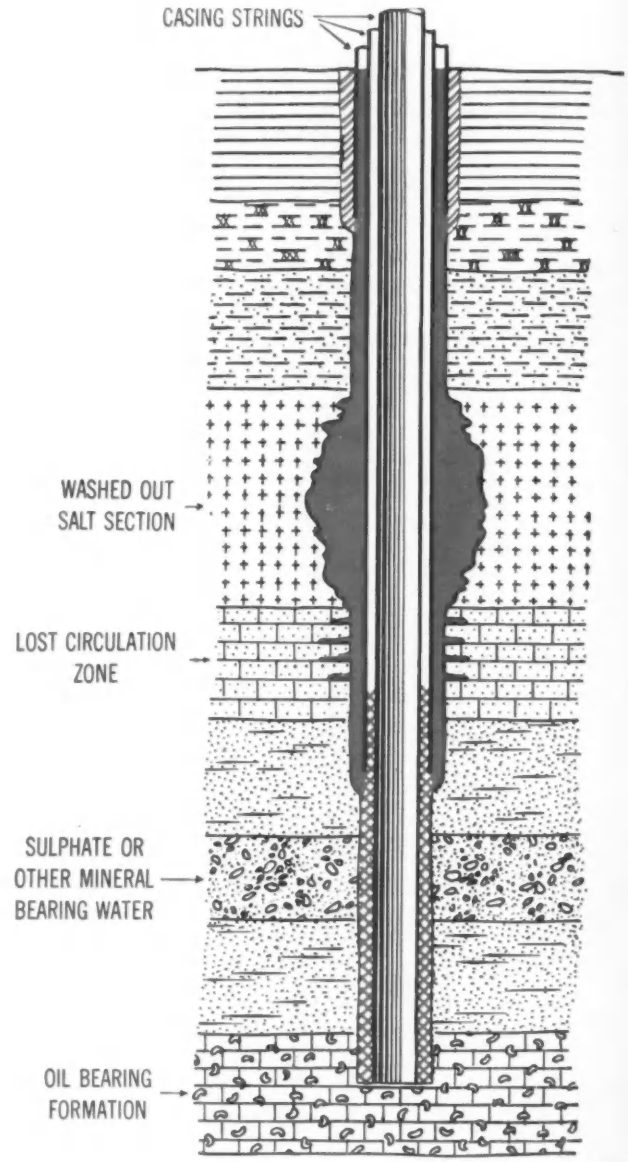

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WORLD OIL

SPECIALIZED FOR EXPLORATION, DRILLING AND PRODUCING OPERATIONS AND MANAGEMENT

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For a "Quick Look" at this issue, turn the page...

a Quick Look at WORLD OIL this month

BUSY OIL MEN: To help you put first things first, scan these time-saving digests on this and the following pages, checking ☑ those you want to read first.

☐ **Adjustment of refinery yields** is the greatest economic need of the U. S. oil industry at this time. Less gasoline and more distillate fuel oil needs to be manufactured. Recent trends in this direction have brightened oil's economic outlook, but continuation of such action is necessary to prevent serious oversupply of motor fuel by the end of the year. See **page 25. Future depends on what refiners do**. . **Warren L. Baker**

☐ **With the outlook for the drilling contractor "not quite so bleak"** as it has been, it still is unlikely that the next few years will see a revival of activity that will bring U.S. totals anywhere near the 1956 peak. Contractors should brace themselves for a long period of adjustment and maintain high efficiency during this low activity period, for their survival depends on their individual fitness. See **page 135. The drilling contractor's future**..... **J. U. Teague**

☐ **Conventional jet bits are used to deviate wells** in lieu of a whipstock. The procedure is especially effective in Texas and Louisiana offshore areas and where soft formations predominate. Requiring fewer round trips and less rig time than conventional directional drilling, the procedure has saved operators thousands of dollars. **Page 137. Jet deflection drilling**..... **Robert W. Scott**

☐ **Record time on two wells** drilled in the Caillou Island area of Louisiana has been attributed to cooperation of crew members and efficient operation of rig equipment. See **page 140** for drilling practices used. **Efficient practices pay off in Gulf Coast operation**..... **Earle C. Hellums and Jack F. Earl**

☐ **Smoother mud pump operation** at higher speeds to achieve greater efficiency is possible by charging the suction line. Controlled tests show the value of adding a supercharger to the mud system. Advantages and disadvantages of this practice, plus easy-to-handle equations for designing a charger installation can be found in the story starting on **page 143. Know Your Mud Pump (Part 4).**
Samuel L. Collier and N. B. Heaps

☐ **Proper selection and maintenance of engine compounds** are important to the drilling contractor. When designing a compound, many important items should be taken into consideration. See **page 149. Proper selection of engine compounds.**
M. Duane Lackey

WORLD OIL'S 1958 SPECIAL

This annual special presentation includes latest technological developments of major importance and interest to all who are affiliated with the drilling phase of the oil industry.

To assure authoritative information for this special issue, several months were spent by WORLD OIL's staff in contacting companies and individuals engaged in operations which reflected both technological and economic progress in the field of drilling.

It is this wealth of new information

☐ **Several new concepts in drilling equipment and techniques** have been observed at the World's Fair in Brussels. See **page 154** for Russia's contribution to the advancement in drilling technology. **Russian advances in equipment and techniques.**
John Workman

☐ **Drilling contractors must look before they leap** into operating in areas abroad. Activity in these areas is increasing as more rigs and personnel be-

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come idle in the U.S. But contractors inexperienced in foreign operation should be sure that they know the pitfalls. See **page 161. A drilling contractor asks: Should I go foreign?**.....**H. T. Brundage**

☐ **Improved jetting principles,** turbine-operated bottomhole devices and reciprocating motors have brought about the need for improved hydraulic horsepower at the bottom of the string. See **page 168** for a discussion of how this is being accomplished. **Maximum hydraulic power at the bit**.....**R. W. Colebrook**

☐ **Recent developments in perforating and fracturing techniques** have resulted in more economical and efficient oil and gas well completions. A properly engineered job can reduce completion costs as much as 25 percent. **Page 173. Engineered completions increase oil recovery**.....**R. W. Coburn**

DRILLING PROGRESS ISSUE

which appears in this issue, beginning on page 135.

In addition to this special report on drilling, latest information on developments in production and exploration operations also is included in this special issue, beginning on page 173.

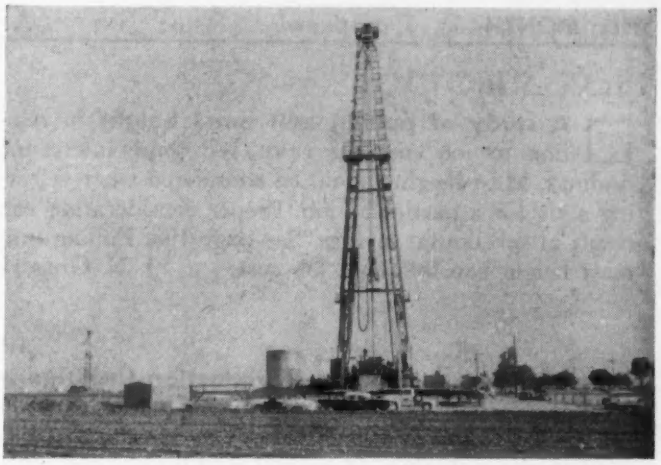
Jack F. Earl

Robert W Scott

Engineering Editors

☐ **Salt dome geology** is discussed on **page 180.** This article will be of interest to all operators concerned with the Gulf Coast salt dome province. In the first of a two-part series, the author takes a fresh look at some time-honored geologic concepts. **A new look at Gulf Coast salt dome geology**..**V. N. Sovinsky**

☐ **The material balance method** can be used to estimate physical reservoir size, original gas in place and other useful reservoir information. Material balance equations for gas reservoirs with and without water influx are presented on **page 182. Gas reservoir material balance can be helpful (part 4)**.**Frank W. Cole**



☐ **California's North Tejon area is shaping up rapidly** as a major high gravity field. Ten wells have been completed to date, with five rigs now working and more expected. For complete details on the geology of the area, plus a description of typical drilling and completion programs, turn to **page 214. North Tejon shaping up as major high gravity field.**

William H. LeRoy and John P. Lavery, Jr.

☐ **A method of establishing equipment standards** is described on **page 183.** Pan American Petroleum Corporation established standards for producing facilities, arrangement of equipment, and certain items of equipment. The procedure followed in field testing new items of equipment is also discussed. **Organizing an equipment standardization program.**

J. Zaba and Henry Schaefer

☐ **A new technique for interpreting gravity data** from easily modified geologic models is an optical analog computer. The instrument has a two-dimensional optical graticule and is well suited for use with geologic features that are long compared to the cross-sections. Turn to **page 188. Optical analog computer simplifies gravity analysis.**

R. W. Baltosser and S. W. Wilcox

☐ **The first commercial discovery** in the Barger field of Red Willow county in 1956 revived interest in the search for petroleum in southwestern Nebraska. Previously, the nearest established oil production was in the Warner field of Decatur County, Kansas, 25 miles to the south. Two additional discoveries in 1958 have increased drilling and leasing activity. See **page 191. Exploration possibilities in southwestern Nebraska look good**.....**Richard F. Svoboda**

☐ **Common V-belt operating problems** and the solutions are discussed on **page 196.** Proper consideration of this useful piece of equipment can mean money in the pockets of field operators. **How you can keep your V-belts healthy**.....**D. A. Locke**

THIS MONTH . . . *continued*

☐ **A study of pulling unit mast height** in relation to job cost has revealed some interesting findings. Mast height should be considered when selecting a rig for a particular job. Proper consideration can result in substantial savings. See **page 198. Pulling unit mast height can influence job cost**.....**J. N. Gregory**

☐ **Microwave controlled production facilities** in the Gulf of Mexico are reducing operating costs for The Pure Oil Company. The program has contributed to the solution of several problems confronting designers of offshore telemetering and supervisory control systems. Turn to **page 203. Microwave radio control developments**. **V. L. Ackerman and W. K. Lewright**

☐ **Automatic custody transfer installations** have become widespread due to proven economics. A considerable amount of work still needs to be done to reduce costs of these installations. Ways in which ACT costs can be reduced are discussed on **page 207. ACT standardization can reduce costs**.....**H. L. Shatto**

☐ **Mapping without ground surveying is achieved** through use of aircraft, together with the science of photogrammetry and electronic survey techniques, such as Shoran and Radio Altimetry. Exploration work in remote and inaccessible areas is greatly facilitated by mapping from the air. Much geological and geophysical information can be obtained without actually setting foot on the ground. Actual applications have included those in the Canadian North and in Guatemala. Turn to **page 210. Photogrammetry and electronic surveys aid remote exploration.**

M. E. Erfle

☐ **Current estimates of ultimate natural gas supply and demand** may well prove to be ultra-conservative. Instead of reserves outpacing production for 17 to 20 years, as per recent estimates, the length of time may be extended past 40 years. For a thought-provoking discussion of U. S. natural gas reserves, past, present and future, turn to **page 222. A new look at ultimate natural gas reserves**.....**Ralph L. Miller**

☐ **Argentina's government has made contracts** under which several U. S. and other private companies will participate in developing that country's petroleum resources. Some of them are on a straight service contract basis. Others involve considerable risk for the companies and potential higher profits. The contracts are expected to go a long way toward fulfilling Argentina's domestic oil needs. **Argentina partially opens door to private oil firms**.....**page 225**

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Indexed by Industrial Arts Index and Engineering Index

Looking Ahead

Crude Output of 7 Million Barrels Daily Needed . . . Market demand for domestic crude oil is expected by IPAA to continue at about 7 million barrels daily during the fourth quarter of this year. Production was at that same level in September.

Other sources supply part of needs . . . Besides the crude production, the supply to meet the fourth quarter demand of 9,720,000 barrels daily will include natural gas liquids production of 850,000 barrels daily, total imports of 1,600,000 daily, and withdrawals from inventories of 270,000 per day.

Crude imports down but product receipts up . . . Total imports will be about the same in October-December, 1958, as in last year's fourth quarter. Crude imports are expected to continue at 900,000 barrels daily, down 100,000 from the final quarter last year. But refined product imports are expected to increase seasonally to 700,000 barrels daily, which would be 100,000 higher than in the final quarter of 1957.

Oil Demand to Be Above Year Ago . . . Demand for petroleum is gradually improving. In the fourth quarter of 1958 total demand will average about 9,720,000 barrels daily. That will be 288,000 a day or 2.7 percent more than in the final quarter of 1957. It is so forecast by Independent Petroleum Association of America.

Domestic use up but exports down . . . Domestic demand will average 9,450,000 barrels daily, up about 330,000 barrels daily or 3.4 percent. But exports of 269,000 daily will be off 75,000 barrels.

Improvement small in recent months . . . In the three months, June-August, 1958, total demand was up only 25,000 barrels daily or 0.3 percent. Domestic consumption of 8,400,000 barrels daily exceeded the year ago level by 180,000 barrels or 2.2 percent. But most of the increase was offset by a sharp decline in exports.

Surplus of Gasoline Threatened . . . There is increasing anxiety over a possible surplus of gasoline in the months ahead. An excess would be especially likely in event of a colder than normal winter.

It now appears that in order to meet the requirements of heating oil in the cold months, refinery runs henceforth are likely to be at a high level that will result in excessive production of gasoline.

Gasoline stocks ample; distillate stocks low . . . Gasoline always accumulates in storage in winter, but a greater than normal build-up now is threatened. Gasoline stocks are as great as a year ago, while distillate fuel oil stocks are 18.5 million barrels under their year-ago level.

Demand better for distillate than for gasoline . . . The demand for gasoline in recent

Continued on next page . . .

months has been only about the same as in the same months last year. But demand for distillate fuel oil has been averaging about 6 percent above the year ago trend. Cold weather could push requirements sharply above last year.

Higher distillate and lower gasoline yields needed . . . The circumstances cited above indicate an urgent need for refiners to increase yields of distillate fuel oil while reducing yields of gasoline.

Imports to Be Based on Refinery Runs . . . Imports of crude and unfinished oils east of the Rockies will be limited under a new plan January 1 to 10.1 percent of total domestic and export demand. Quotas of individual importers will be based on their refinery runs instead of their former imports. Present larger importers will be required to reduce imports by stages. Present smaller importers will gain increased quotas.

Drilling Retarded by Imports and Gas Price Control . . . Lagging of U. S. drilling may continue for several years, predicted J. E. Swearingen, president, Standard Oil Co. (Ind.). The current letdown reflects, he said, not only the recession but also other deterrents, including large imports and federal control of wellhead prices of gas.

Persian Gulf Oil Area Extended Eastward . . . A new offshore field in the Persian Gulf is the third within the gulf and the most easterly in the region. It is 20 miles east of Das Island, which is 60 miles offshore from Abu Dhabi. The field is 170 sea miles from Bahrain and east of Qatar's Dukhan field.

The discovery well is Umm Shaif 1 of Abu Dhabi Marine Areas, Ltd. (⅔ British Petroleum Co. and ⅓ Compagnie Francaise des Petroles). It was drilled to 8,755 feet, where Arab Zone limestones (Jurassic) yielded gas on tests. The well previously flowed 40 gravity oil, 1.4 percent sulfur content, from Shuaiba limestone (Cretaceous) at the rate of 2,400 barrels daily.

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The latest ABC report shows WORLD OIL among the leaders in meeting these high standards of publishing integrity. And we plan to remain among the leaders by continuing to live up to the rigid requirements of ABC, the publishing industry's guarantee of high quality editorial content and circulation.

We value highly the ABC symbol on Page 6. It represents our constant challenge to give our readers their money's worth every month.

Not perfect, but better

From the federal government has come another move designed to control imports of foreign crude oil. This latest program, evolved by U. S. Imports Administrator Matthew V. Carson, Jr., and tailored by a government task force, changes the method of controlling oil imports. The proposal would substitute a percentage-of-refinery-run control for the historical allocation system.

In seeking the most equitable manner of better controlling crude imports, Captain Carson set aside a period of 30 days in which industry's comments on the new program will be accepted for study. At the end of this "study period," it is likely that the new voluntary program or a modified version will go into effect.

This proposed program will run the old and familiar gamut of opinion—from outright support to vehement dislike. That is to be expected since, under the new approach, oil imports of some companies will be increased, others will remain at present levels and still others will be reduced. Differences of opinion naturally can be expected to follow the trend of the impact of the new program on individual companies.

But regardless of how much is written or what is said in criticism of the proposal, it represents an improvement over the present system from an over-all industry viewpoint.

For the first time, imports would be tied directly to a fluctuating activity of the domestic industry. Imports would be geared to crude oil demand, the same basis used by leading oil states in setting domestic producing rates.

Because of the tie-in of imports with demand, the new plan emphasizes domestic production during future growth periods. It permits both domestic production and imports to fluctuate in accordance with changing economic requirements on a pre-established basis. This will permit long-range planning by producers, refiners and importers.

The program offers producers hope for a more stable and effective way to control imports. And it likely will require far less revision through the years than the import allocation plan has required since its inception.

The 30-day "study period" offers all segments of the industry and all companies an opportunity to express their views on the proposed new plan. Everyone should take advantage of this invitation.

In doing this, all should be as constructive as possible. Benefits of certain phases should be pointed out along with the defects of other portions of the plan. Most important of all, along with criticism of the defects should come constructive suggestions for improvement.

If all will put their best efforts forward, it is likely that some of the problems can be ironed out. This would enhance the chances of designing the best type of program for the greatest number of interested groups.

It behooves the industry to do its utmost to work out a fairly satisfactory program. This would be better than the frequently cussed and discussed alternative: mandatory government controls.

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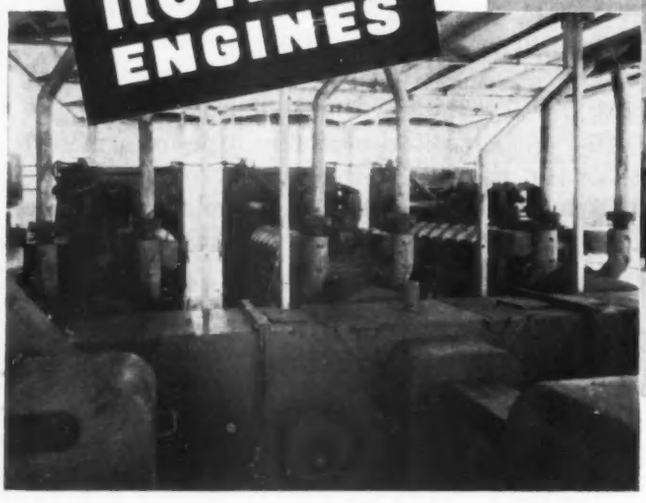

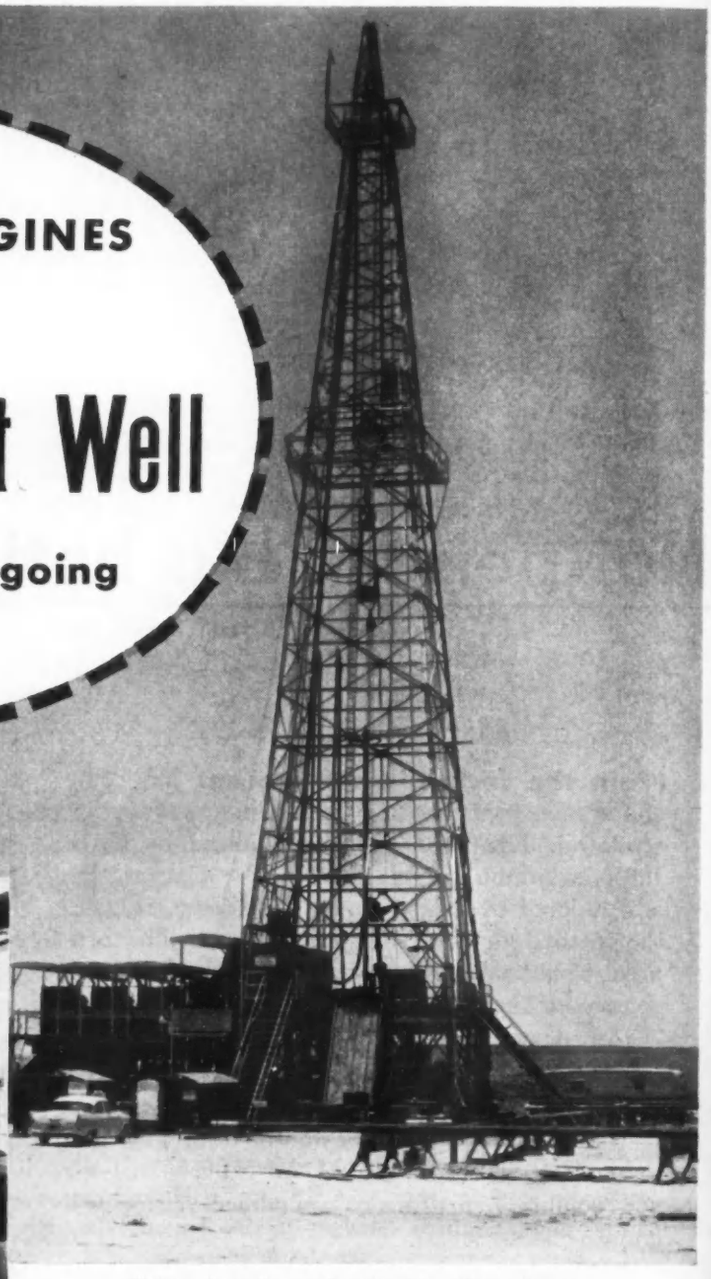

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Warren L. Baker, Editorial Director

Future depends on what refiners do

Crude stocks in excellent condition, but prospects are bleak unless refining yields are adjusted to produce less gasoline and more distillate fuel oil

Oil's outlook brightened further in recent weeks. Chief cause of the improvement was an adjustment of U. S. refinery yields, which had the effect of enlarging drafts on gasoline inventories and simultaneously increasing additions to distillate stocks. This was a badly needed move to prevent excessive motor fuel stocks and to build distillate inventories to desirable levels.

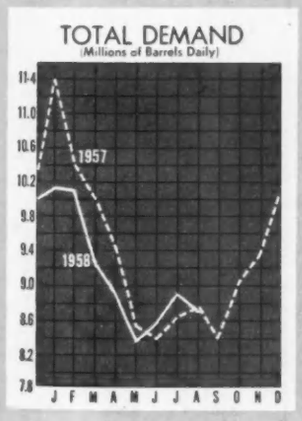
However, this problem has not been solved completely as yet. The industry must continue to regulate its refinery runs and particularly refinery yields to further alleviate a serious imbalance between gasoline and distillate inventories.

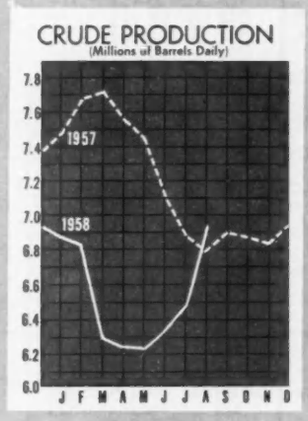
The next three months will be a decisive period for the industry. Refining activity during these months will determine whether the industry's economic condition for the first half of 1959 is to be good or bad. The outcome depends on the industry's own management of refinery operations.

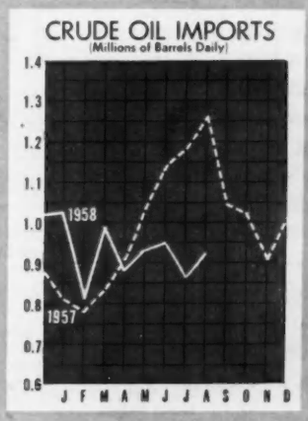
Time is getting very short for the industry to take corrective measures to reduce gasoline stocks and increase distillate fuel inventories. It would have been much easier for the industry to have adjusted its refinery yields of gasoline and distillate fuel to proper amounts during summer months, when gasoline demand was higher and distillate fuel demand lower. Instead, far too much gasoline was manufactured. Refiners seemingly wished to drown themselves in a flood of unneeded gasoline.

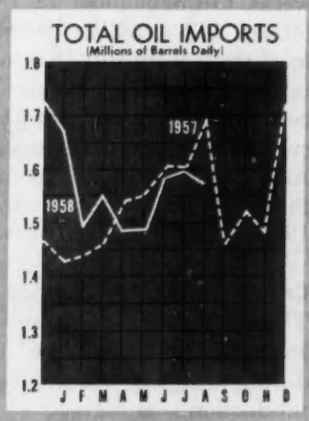
Recent adjustments in refinery yields are extremely encouraging. But, the industry must continue these ad-

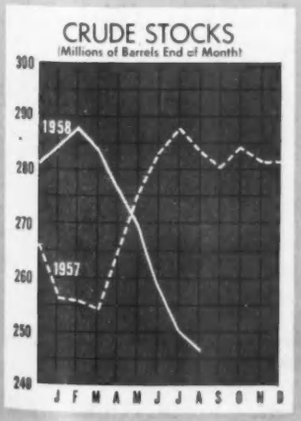
Petroleum Trends...

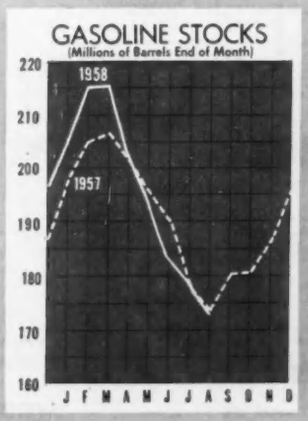


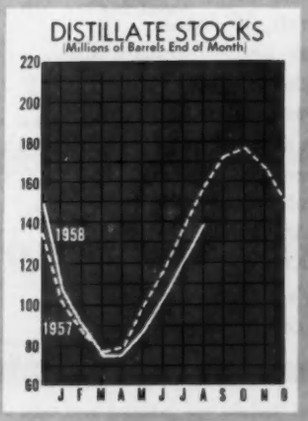


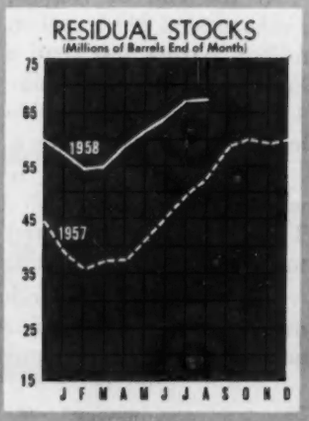












justments in the months ahead. If this is done, the industry's outlook can be improved materially.

Unless the situation is corrected, the industry's whole economic picture will be bleak. Refining profits are pegged to gasoline, the biggest product of the industry. When gasoline prices are weakened by excessive supply, the industry's whole price structure suffers. This includes crude oil prices. When refiners are not making reasonable profits, heavy pressure comes to bear on the price they will pay for crude oil.

The importance of making such adjustments in refinery yields is shown by changes in the industry's recent statistical position.

Total inventories of gasoline on September 12 totaled 172.9 million barrels, nearly one million barrels below a year ago. Four weeks before, gasoline stocks had been 4⅓ million barrels higher than a year ago, and therefore quite excessive. But, the situation has not improved as much as the national figures indicate. Gasoline stocks located outside of the West Coast were still 1.6 million barrels greater than a year ago on September 12, consequently considerably too high.

Meanwhile, total inventories of distillate fuel rose sharply during recent weeks. On September 12, these stocks totaled 172.9 million barrels. At this level there were still 16.8 million barrels below year ago levels. There has been some improvement, but not enough, since distillate stocks in mid-August were 18 million barrels less than the corresponding period of 1957.

Crude stocks are in good condition. They remain well below year ago levels. They continued to decline during August, although crude oil production was higher.

At the end of August, crude oil stocks totaled 247.1 million barrels, 36 million barrels less than a year ago. East of California, crude stocks are 41.5 million barrels below year ago levels.

Thus, the industry is operating with very low crude oil inventories. They should be increased somewhat to provide better operating efficiency.

Consequently, the industry's immediate future relies entirely on the action of refining companies.

U. S. Monthly Oil Trends

(THOUSANDS OF BARRELS DAILY)

	AUGUST			July	JANUARY–AUGUST		
	1958	1957	%Diff.	1958	1958	1957	%Diff.
U.S. Crude Oil Production	6,873	6,789	+ 1.2	6,504	6,521	7,324	—11.0
U.S. Nat. Gas Liquids Prod	790	786	+ 0.5	780	781	803	— 2.7
U.S. Total Imports	1,567	1,695	— 7.6	1,597	1,621	1,541	+ 5.2
East Coast Crude Imports	723	961	—24.8	685	755	743	+ 1.6
Total Crude Imports	923	1,257	—26.6	852	926	996	— 7.0
Total Refined Products	644	438	+47.0	745	695	545	+27.5
Total New Supply	9,230	9,267	— 0.4	8,826	8,916	9,669	— 7.8
Stock Changes All Oils (Daily)	+490	+539	.....	— 99	—224	+229	.....
Total Demand All U.S. Oils	8,740	8,728	+ 0.1	8,925	9,140	9,440	— 3.2
Gasoline Demand	4,158	4,262	— 2.5	4,275	3,924	3,979	— 1.4
Distillate Fuel Demand	1,121	1,175	— 4.6	1,210	1,744	1,785	— 2.3
Residual Fuel Demand	1,310	1,367	— 4.2	1,300	1,439	1,626	—11.5
Domestic Demand, All Oils	8,490	8,324	+ 2.0	8,675	8,879	8,768	+ 1.3
Export Demand, All Oils	250	404	—38.1	250	261	672	—61.2
Crude Runs U.S. Refineries	7,803	8,092	— 3.6	7,564	7,507	7,994	— 6.1
Domestic Crude Runs	6,783	6,852	— 1.0	6,658	6,573	7,018	— 6.4
Foreign Crude Runs	1,020	1,239	—17.7	906	934	976	— 4.3

	TOTAL U.S. STOCKS Millions of Barrels End of Month				STOCKS EAST OF CALIFORNIA Millions of Barrels End of Month			
	AUGUST			July	AUGUST			July
	1958	1957	%Diff.	1958	1958	1957	%Diff.	1958
Crude Oil	247.1	283.4	—12.8	249.9	205.5	247.0	—16.8	207.5
Gasoline	173.8	174.0	— 0.1	178.7	150.5	148.7	+ 1.2	153.6
Distillate Fuel Oil	139.6	159.1	—12.3	120.4	125.4	142.7	—12.1	107.1
Residual Fuel Oil	67.5	52.6	+28.3	66.9	34.1	33.2	+ 2.7	34.3
Kerosine	28.7	34.6	—17.1	28.7	28.4	34.2	—17.0	25.5

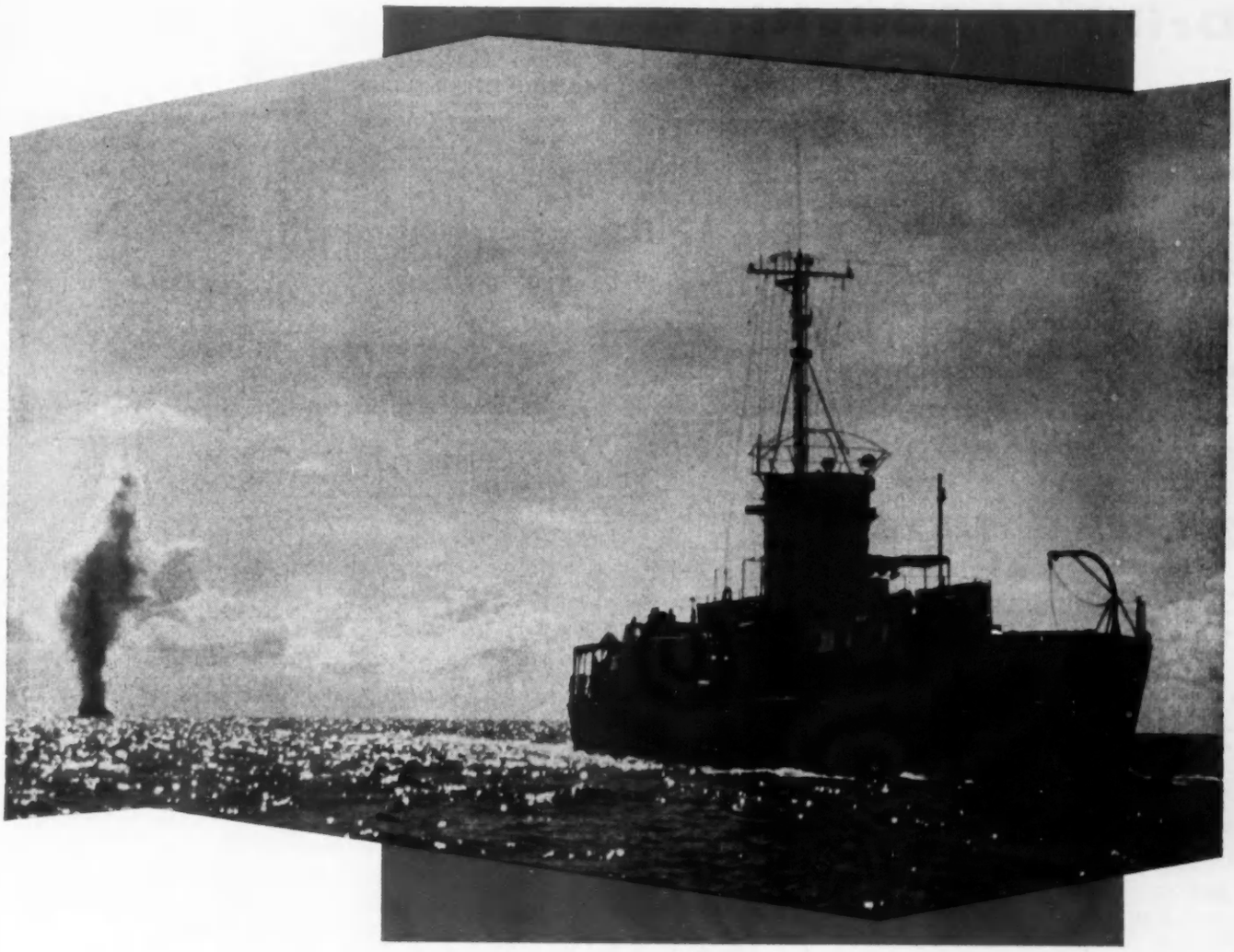
Source: Except for latest two months, all data from U.S. Bureau of Mines. Data for last two months from American Petroleum Institute weekly reports and U.S. Bureau of Mines weekly crude stock report; except U.S. Natural Gas Liquids Production and Demand figures which are estimated by World Oil

U. S. Crude Production By States

(THOUSANDS OF BARRELS)

STATE or DISTRICT	DAILY AVERAGE PRODUCTION August 1958	August 1957	% Diff.	July 1958	TOTAL PRODUCTION January–August 1958	January–August 1957	% Diff.
Alabama	17.0	14.5	+ 17.2	17.7	3,912	3,486	+ 12.2
Arkansas	74.2	81.0	— 8.4	74.7	18,964	20,422	— 7.1
California	858.5	930.2	— 7.7	854.9	210,962	226,261	— 6.8
Colorado	131.0	148.1	— 11.6	133.8	32,715	37,251	— 12.2
Florida	1.2	1.3	— 7.7	1.2	302	305	— 1.0
Illinois	223.4	189.2	+ 18.1	225.4	54,368	49,790	+ 9.2
Indiana	31.8	33.7	— 5.6	30.9	7,768	8,613	— 9.8
Kansas	332.8	328.3	+ 1.4	318.7	77,525	80,612	— 3.8
Kentucky	41.4	46.5	— 11.0	42.1	10,449	11,297	— 7.5
Louisiana	848.9	788.8	+ 7.6	814.8	200,507	224,859	— 10.8
North Louisiana	106.6	115.0	— 7.3	106.2	27,358	32,160	— 14.9
South Louisiana	742.3	673.8	+ 10.2	708.6	173,149	192,699	— 10.2
Michigan	25.2	27.4	— 8.0	24.5	6,148	6,871	— 10.5
Mississippi	101.1	93.4	+ 8.2	98.9	23,854	26,555	— 10.2
Missouri-Tennessee-South Dakota	0.4	0.3	+ 33.3	0.3	85	62	+ 37.1
Montana	77.0	77.2	— 0.3	77.5	18,662	17,854	+ 4.5
Nebraska	58.6	58.0	+ 1.0	55.5	13,156	12,454	+ 5.6
Nevada	0.1	.....	.....	0.1	20	19	+ 5.3
New Mexico	277.6	256.6	+ 8.2	280.3	64,464	63,200	+ 2.0
Southeast New Mexico	249.9	249.6	+ 0.1	249.2	59,670	61,716	— 3.3
Northwest New Mexico	27.7	7.0	+295.7	31.2	4,794	1,484	+223.0
New York	5.1	7.3	— 30.1	4.5	1,426	1,809	— 21.2
North Dakota	34.4	40.2	— 14.4	37.9	9,559	9,653	— 1.0
Ohio	16.0	14.9	+ 7.4	16.7	4,143	3,459	+ 19.8
Oklahoma	564.2	557.9	+ 1.1	555.6	134,031	145,480	— 7.9
Pennsylvania	17.2	22.5	— 23.6	18.2	4,540	5,592	— 18.8
Texas	2,703.5	2,771.1	— 2.4	2,401.2	598,167	749,722	— 20.2
Dist. 1: South Central	45.7	51.0	— 10.4	43.5	11,090	13,394	— 17.2
Dist. 2: Middle Gulf	124.9	133.3	— 6.3	103.9	26,758	37,203	— 28.1
Dist. 3: Upper Gulf	378.3	425.7	— 11.1	358.2	89,519	110,924	— 19.3
Dist. 4: Lower Gulf	201.4	214.4	— 6.1	182.5	44,244	57,435	— 23.0
Dist. 5: East Central	32.5	35.9	— 9.5	26.6	7,087	9,766	— 27.4
Dist. 6: Northeast	277.8	298.5	— 6.9	234.7	59,879	82,756	— 27.7
Dist. 7-B: North Central	142.9	150.2	— 4.9	124.9	32,383	39,561	— 18.2
Dist. 7-C: West Central	136.2	145.5	— 6.4	126.1	31,143	40,278	— 22.7
Dist. 8: West	1,051.7	1,026.1	+ 2.3	909.9	217,764	277,968	— 21.7
Dist. 9: North	206.0	203.0	+ 1.5	186.7	47,344	51,322	— 7.8
Dist. 10: Panhandle	106.0	106.6	— 0.6	104.0	25,841	25,536	+ 1.2
Utah	100.0	10.4	+861.5	89.1	12,977	2,429	+434.3
Virginia	.....	.....	.....	.....	3	.....	.....
Washington	.....	.....	.....	.....	7	.....	.....
West Virginia	6.1	6.0	+ 1.7	6.2	1,460	1,462	— 0.1
Wyoming	326.6	281.6	+ 16.0	322.6	74,525	70,232	+ 6.1

Source: Bureau of Mines and API. Texas Districts from API and do not necessarily agree with state totals.



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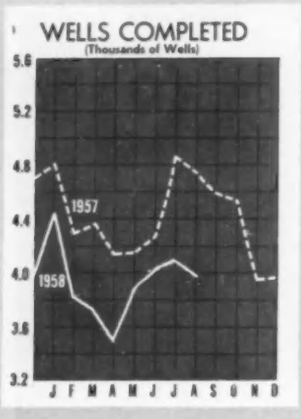
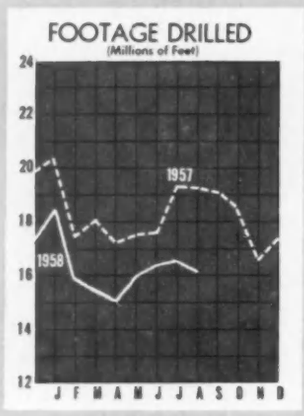
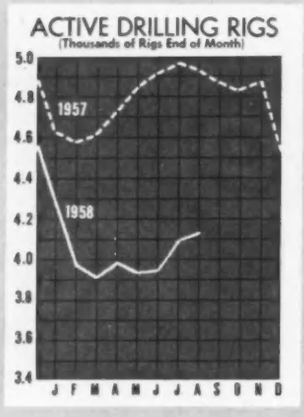
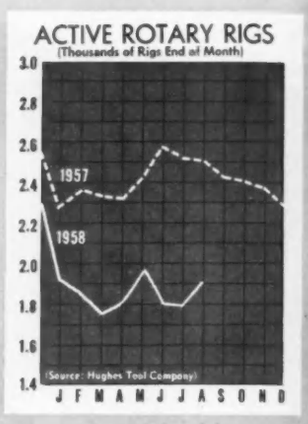
Drilling Activities...









Well completions in August fall just below 4,000 mark

AGAIN, IN AUGUST, new well completions hovered at the 4,000-well level. During each of the two previous months, completions exceeded 4,000 wells. In the meantime, no significant slackening in drilling activity is anticipated in September.

New completions recorded in August totaled 3,994, almost on a par with the 4,143 completions in July and with the 4,129 accounted for during June. These figures compare with the low of 3,553 for the year which was reported for April.

Continued drilling activity at this pace would mean the completion of approximately 16,000 wells during the final four months of the year. A total of 31,399 wells was completed during the first eight months of 1958, therefore, chances are good that WORLD OIL's forecast of 47,952 completions in the U. S. for this year will be reached.

Another slight increase in the number of rigs in operation during August indicates that completions during September again will be at or above the 4,000-well completion level. At the close of August, 4,125 rigs were in operation in the U. S. as compared with 4,098 rigs at the end of July, 4,076 at the end of June, 3,938 at the close of May, 3,996 at the end of 4,076 at the end of June, 3,938 at the close of March.

The 149 fewer well completions recorded in August as compared with July resulted in a decrease in footage drilled of 429,613 feet. However, the July footage level of 16,551,586 was the largest amount of footage drilled in any month since January.

Still Below Last Year. Although the increase in wells and footage during recent months, 1958 rates remain considerably below the figures for the previous year.

U. S. well completions in August last year reached 4,770, only 75 wells less than the 1957 record which was set in July of that year. A total of 4,845 completions was reported for that month. That accelerated activity slackened, however, and new well completions declined steadily in succeeding months to reach a low of less than 4,200 completions during the last two months of the year.

Completion of 31,399 wells during the first eight months of this year is an even 12 percent under the 35,691 wells completed during the safe period of 1957. During the first eight months of 1958, footage has totaled 129.2 million feet, or an almost paralleling drop of 12.2 percent from the 147.1 million feet drilled during the similar period of 1957.

Texas Drops. Fewer wells were completed in Texas during August than in the preceding month. A total of 1,360 new wells was completed in the state in August as contrasted with 1,531 new wells in the previous month. Only the Middle Gulf Coast, Upper Gulf Coast and Gulf of Mexico regions completed more wells in August than in July.

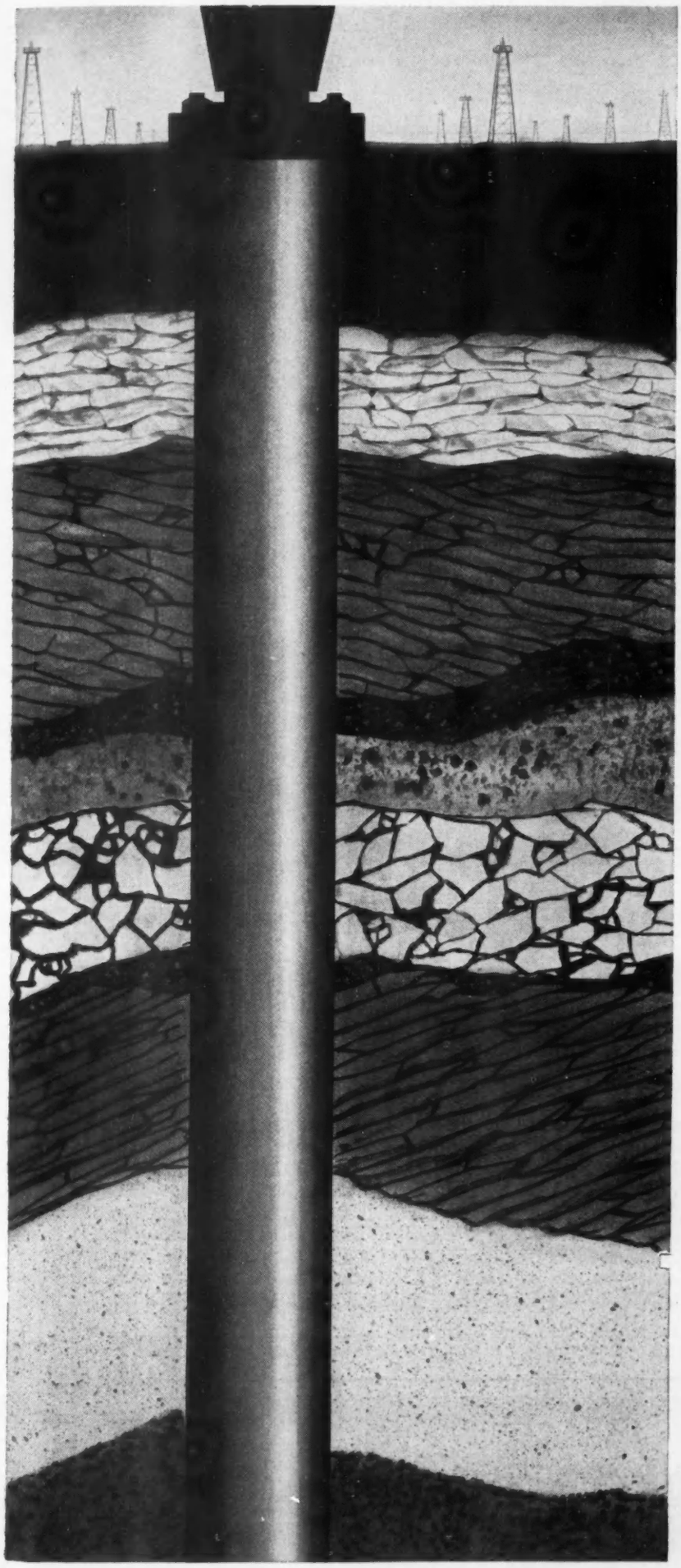
Summary of U. S. Drilling Activity

ITEM	Aug. 1958	July 1958	EIGHT MONTHS January-August 1958	1957	% Dif.
New Wells Completed:					
Oil	1,883	2,052	15,628	18,715	— 16.5
Distillate	71	52	509	470	+ 8.3
Gas	368	378	2,705	2,441	+ 10.8
Service	100	124	884	698	+ 26.6
Dry	1,572	1,537	11,673	13,367	— 12.7
Total Wells	3,994	4,143	31,399	35,691	— 12.0
Footage Drilled (Mln. of Feet)	16.1	16.6	129.2	147.1	— 12.2

Summary of U. S. Wildcat Drilling

ITEM	Aug. 1958	July 1958	EIGHT MONTHS January-August 1958	1957	% Dif.
New Field Discoveries:					
Oil	53	56	484	554	— 12.6
Distillate	8	5	64	83	— 22.9
Gas	18	25	158	150	+ 5.3
Total Discoveries	79	86	706	787	— 10.3
Dry Wildcats	729	770	5,599	6,782	— 17.5
Total Wildcats	808	856	6,305	7,569	— 16.7
Percent Productive	9.8	10.0	11.2	10.4	.....
Percent Dry	90.2	90.0	88.8	89.6	.....

Details on Page 30



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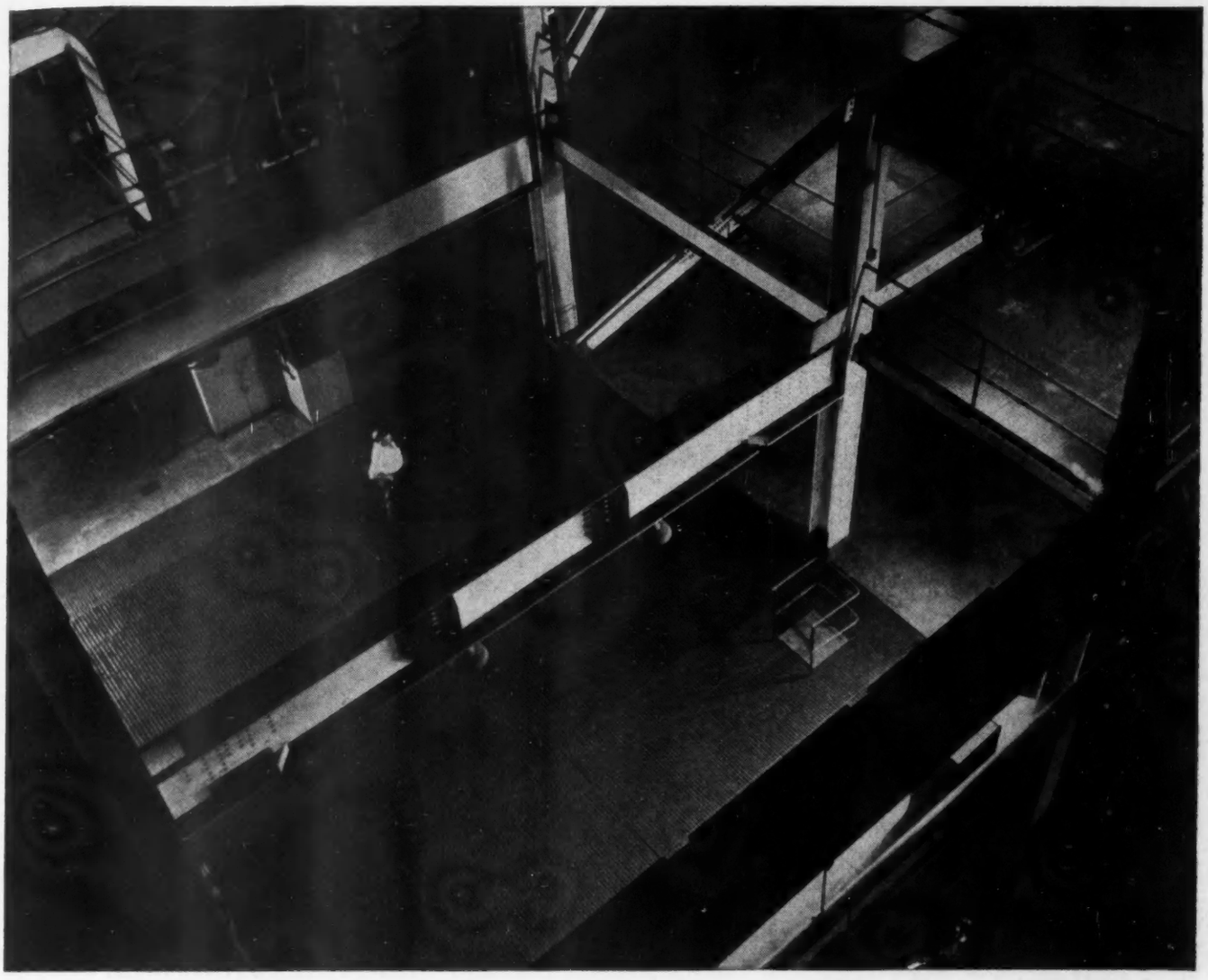
U. S. Drilling Activity in August and First Eight Months, 1958-1957

STATE or DISTRICT	TOTAL NEW WELLS COMPLETED AND FOOTAGE DRILLED — DETAILS FOR AUGUST, 1958					TOTAL NEW WELLS			Total Footage August 1958	DETAILS FOR JANUARY-AUGUST					WILDCAT DRILLING IN AUGUST AND FIRST EIGHT MONTHS, 1958-1957 — DETAILS FOR AUGUST, 1958					DETAILS FOR JANUARY-AUGUST					DRILLING RIGS IN OPERATIONS (Rigging up, Drilling, Tem. Shut-down)		
										NEW WELLS			FOOTAGE										TOTAL WILDCATS				
	Oil	Dist.	Gas	Dry	Service Wells	Aug. 1958	July 1958	Aug. 1957		1958	1957	Percent Diff.	1958	1957	Oil	Dist.	Gas	Dry	Total Wildcats	Oil	Dist.	Gas	Dry	1958	1957	Aug. 31, 1958	July 31, 1958	Aug. 31, 1957
Alabama	3	....	....	3	....	6	7	4	47,735	51	71	— 28.2	431,122	613,827	....	....	....	3	3	....	....	....	19	19	26	13	14	8
Arkansas	58	1	3	39	....	101	65	123	317,760	496	739	— 32.9	1,658,296	2,206,267	....	....	....	12	12	6	1	6	90	103	110	49	54	69
California	50	....	8	40	1	99	100	182	561,827	947	1,447	— 34.6	4,548,966	6,179,401	1	....	1	21	23	6	....	2	156	164	243	134	136	178
Colorado	15	....	7	55	....	77	97	65	396,175	555	533	+ 4.1	2,882,548	2,775,902	3	....	1	39	43	20	....	11	269	300	326	65	74	66
Florida	....	....	....	1	....	1	2	....	6,915	5	8	— 37.5	48,804	57,082	....	....	....	1	1	....	....	....	5	5	8	2	2	....
Georgia	....	....	....	....	....	....	....	....	....	....	3	—100.0	....	18,955	....	....	....	....	....	....	....	....	....	....	3	1	1	....
Illinois	84	....	2	128	....	214	215	294	478,500	1,447	1,705	— 15.1	3,304,142	3,860,022	....	....	....	66	66	2	....	....	377	379	503	301	282	258
Indiana	21	....	....	41	1	63	82	80	104,856	482	438	+ 10.0	795,379	710,951	....	....	....	14	14	3	....	1	120	124	122	109	102	120
Kansas	130	....	21	157	12	320	321	367	1,077,888	2,324	2,768	— 16.1	7,997,912	9,844,456	11	....	1	63	75	78	....	18	517	613	672	335	396	563
Kentucky	53	....	16	75	2	146	139	191	221,395	946	1,111	— 14.9	1,384,072	1,649,601	2	....	1	8	11	6	....	2	40	48	80	118	120	139
Louisiana	166	20	18	127	....	331	302	324	2,326,432	2,288	2,428	— 5.8	18,369,013	19,381,803	3	2	1	50	56	24	14	5	335	378	391	360	347	427
North Louisiana	72	....	11	62	....	145	115	144	518,196	820	898	— 8.7	3,109,013	3,284,676	1	....	....	30	31	9	....	....	107	116	113	93	105	83
South Louisiana	94	20	7	65	....	186	187	180	1,808,236	1,468	1,530	— 4.1	15,260,000	16,097,127	2	2	1	20	25	15	14	5	228	262	278	267	242	344
*Gulf of Mexico	36	6	1	12	....	55	41	34	539,215	355	437	— 18.8	3,404,922	4,086,919	....	....	1	4	5	3	1	1	26	31	51	35	42	95
Michigan	8	....	1	19	....	28	42	41	70,867	249	261	— 4.6	726,138	750,846	....	....	....	12	12	5	....	2	78	85	94	78	69	75
Mississippi	16	2	2	15	....	35	35	41	290,362	247	250	— 1.2	2,213,516	1,801,992	....	....	....	10	10	9	1	....	91	101	135	50	40	49
Missouri	....	....	....	1	....	1	2	1	3,600	11	4	+175.0	9,872	4,169	....	....	....	1	1	....	....	....	4	4	4	2	2	....
Montana	12	....	....	11	1	24	18	41	103,161	203	263	— 22.8	1,086,893	1,335,512	....	....	....	8	8	5	1	4	74	84	89	40	46	47
Nebraska	13	....	....	38	....	51	54	90	298,253	420	597	— 29.7	2,495,337	3,528,865	1	....	....	23	24	19	....	....	175	194	310	44	42	40
Nevada	....	....	....	....	....	....	....	1	....	....	4	—100.0	....	10,568	....	....	....	....	....	....	....	....	....	....	4	1	1	2
New Mexico	94	4	62	50	....	210	166	159	976,388	1,345	1,466	— 8.3	6,353,121	6,741,703	2	....	1	24	27	24	2	16	145	187	204	169	195	192
Southeast	67	3	3	32	....	105	72	86	519,628	688	899	— 23.5	3,425,347	4,403,785	1	....	....	17	18	17	2	4	90	113	134	61	56	103
Northwest	27	1	59	18	....	105	94	73	456,760	657	567	+ 15.9	2,927,774	2,337,918	1	....	1	7	9	7	....	12	55	74	70	108	139	89
New York	15	....	1	2	17	35	35	48	56,250	358	327	+ 9.5	555,300	533,900	....	....	....	....	....	....	....	....	....	....	....	42	42	58
North Dakota	24	....	....	16	....	40	50	18	248,923	286	171	+ 67.3	1,891,134	1,202,548	1	....	....	11	12	18	....	....	71	89	77	31	40	40
Ohio	38	....	24	30	....	92	87	79	233,307	660	654	+ 0.9	1,702,337	1,562,399	....	....	....	3	3	....	....	....	7	7	6	225	232	208
Oklahoma	268	9	28	183	41	529	568	519	1,620,341	4,746	3,880	+ 22.3	14,851,171	14,071,238	2	3	4	49	58	45	10	24	424	501	442	445	442	606
Pennsylvania	18	....	26	7	8	59	54	96	185,911	397	635	— 37.5	979,214	1,699,741	....	....	....	....	....	....	....	....	....	....	30	175	162	189
South Dakota	....	....	....	2	....	2	....	3	5,196	5	30	— 83.3	22,187	113,525	....	....	....	2	2	....	....	....	5	5	28	4	2	1
Texas	742	35	94	472	17	1,360	1,531	1,808	5,798,337	11,642	14,805	— 21.4	49,605,844	62,173,798	27	3	8	278	316	208	35	57	2,396	2,696	3,408	980	933	1,267
Dist. 1: South Central	28	1	1	31	....	61	64	87	142,531	641	884	— 27.5	1,562,872	2,231,911	....	....	....	23	23	9	1	1	225	236	250	34	36	52
Dist. 2: Middle Gulf	15	11	7	29	....	62	57	78	389,644	480	525	— 8.6	2,900,794	3,270,912	....	1	1	23	25	8	7	8	132	155	179	34	37	28
Dist. 3: Upper Gulf	38	6	11	51	....	106	94	159	692,033	867	1,162	— 25.4	5,540,734	7,730,882	1	....	1	31	33	6	3	6	223	238	311	67	72	114
*Gulf of Mexico	....	....	....	1	....	1	....	1	9,915	9	7	+ 28.6	72,271	52,372	1	....	....	....	1	1	....	1	5	7	3	....	1	....
Dist. 4: Lower Gulf-S.W.	33	11	9	43	....	96	109	145	534,768	814	984	— 17.3	4,184,145	5,158,108	2	1	1	28	32	16	11	5	292	324	300	54	64	83
*Gulf of Mexico	....	....	....	....	....	....	1	4	....	7	16	— 56.3	75,300	161,150	....	....	....	....	....	....	....	....	2	2	2	....	....	2
Dist. 5: East Central	....	....	2	10	....	12	29	12	65,452	126	108	+ 16.7	473,217	483,861	....	....	1	5	6	2	1	1	71	75	75	14	16	18
Dist. 6: Northeast	33	2	4	24	....	63	68	92	353,967	558	733	— 23.9	2,943,772	3,967,723	1	1	1	13	16	5	3	3	132	143	170	65	53	63
Dist. 7-B: North Central	83	....	2	97	1	183	195	220	559,819	1,438	1,827	— 21.3	4,631,607	6,182,697	11	....	1	59	71	55	3	7	441	506	665	79	61	03
Dist. 7-C: West Central	32	....	5	18	2	57	70	84	245,530	534	800	— 33.3	2,649,525	3,622,859	2	....	....	10	13	22	....	4	129	155	235	71	64	85
Dist. 8: West	254	1	6	56	1	318	351	431	1,543,232	2,817	3,399	— 17.1	13,590,232	16,667,262	7	....	....	36	43	49	1	4	288	342	359	290	291	371
Dist. 9: North	172	....	16	99	12	299	381	362	844,024	2,506	3,391	— 26.1	7,275,773	8,954,467	2	....	....	42	44	27	2	5	399	433	777	169	153	227
Dist. 10: Panhandle	54	3	31	14	1	103	113	138	427,337	861	992	— 13.2	3,853,173	3,903,116	1	....	1	8	10	9	3	13	64	89	87	103	86	123
Utah	13	....	2	7	....	22	50	20	104,579	294	132	+122.7	1,628,043	753,285	....	....	....	5	5	....	....	....	58	58	60	35	41	75
Washington	....	....	....	....	....	....	....	1	....	4	4	....	20,794	20,459	....	....	....	....	....	....	....	....	3	3	3	....	....	1
West Virginia	17	....	42	12	....	71	61	77	187,263	510	419	+ 21.7	1,328 186	1,128,662	....	....	....	....	....	....	....	6	4	10	14	195	192	170
Wyoming	25	....	9	38	....	72	56	96	366,172	451	533	— 15.4	2,205,705	2,341,520	....	....	....	23	23	8	....	3	121	132	172	114	84	91
Others	....	....	2	3	....	5	4	1	33,580	30	5	+500.0	115,631	18,844	....	....	....	3	3	....	....	1	15	16	5	8	5	6
Total United States	1,883	71	368	1,572	100	3,994	4,143	4,770	16,121,973	31,399	35,691	— 12.0	129,210,677	147,091,841	53	8	18	729	808	484	64	157	5,599	6,305	7,569	4,125	4,098	4,945
Total Western Canada	120	....	29	54	18	221	184	319	1,045,589	1,527	2,061	— 25.9	7,938,511	13,968,509	....	....	....	....	....	....	....	....	....	....	....	238	229	231

* Gulf of Mexico wells are included in their respective district total.



Blaw-Knox Electroforged® Steel Grating provides removable floors to simplify plant operation

Floors and mezzanines made of Blaw-Knox grating solve the problem of reaching, moving and servicing the largest types of equipment. Sections come up easily, allowing ample space to maneuver and maintain any size of machinery. Costly, time-consuming alterations are virtually eliminated.

For increased plant safety Blaw-Knox Electroforged Steel Grating provides rigid one-piece construction for sure support of the heavy loads. Non-slip cross bars and a wide variety of bearing bars assure safe walking and climbing — even under the most hazardous working conditions.

Because there's nothing to wear, or patch, nothing to catch and retain dirt, upkeep becomes easy and economical. And grating's maximum open area admits more air and light, makes brighter, better-ventilated plants.

Blaw-Knox Electroforged Steel Grating for walkways, stair treads and floors is fabricated to meet your specific operating needs. For new ideas about a complete line of space saving grating, write for Bulletin 2527 featuring grating and treads.

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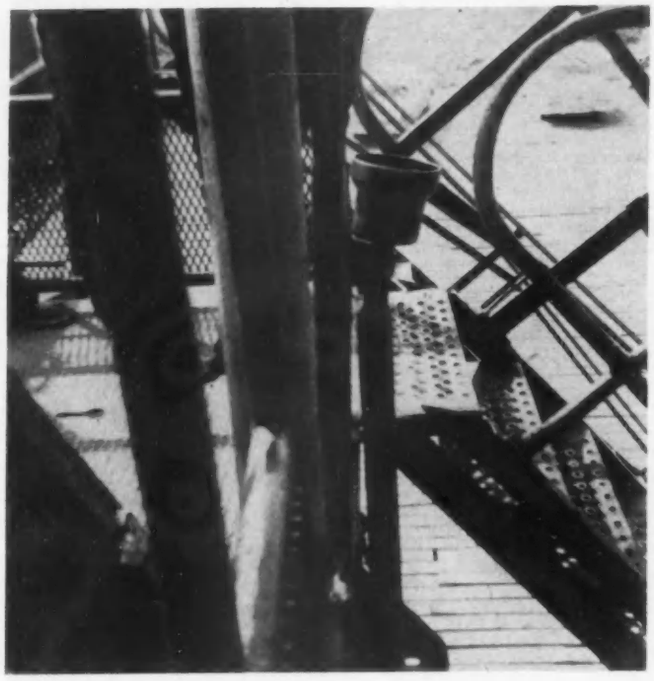
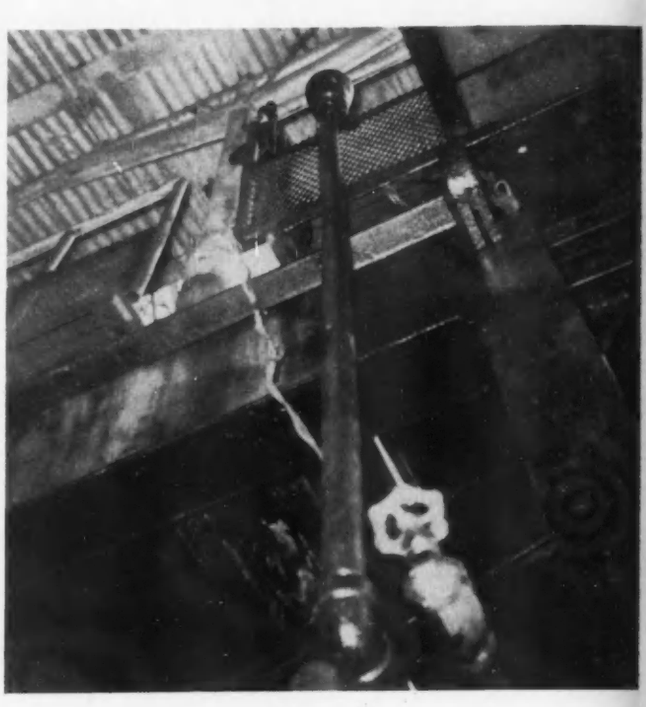
Practical Operating Hints

These **How-To-Do-It** Ideas Can Save You Money

$10 is paid for each illustrated acceptable contribution. Mail to The Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas

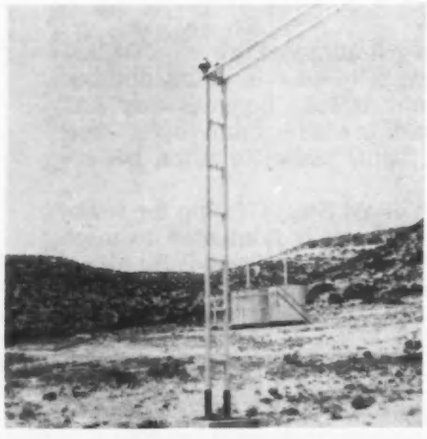




Fill Hydraulic Brake Oil Reservoir From Rig Floor

To save steps, a Gulf Coast contractor rigged a method whereby the driller could fill the hydraulic brake oil reservoir located below the rig floor from the derrick floor.

This was accomplished by extending the reservoir fillup line with a 2-inch pipe horizontally to the outside edge of the rig floor; then with the aid of an elbow and another length of 2-inch pipe, the line was extended to the rig floor where it was secured to the guard rail. To facilitate pouring a funnel was inserted into the 2-inch pipe. Before this extension was made it was necessary to crawl under the substructure to fill the reservoir.



Unique Vent Line Support Made of 2 Vertical Risers

This easily constructed tank vent line support is a useful, convenient addition to any lease.

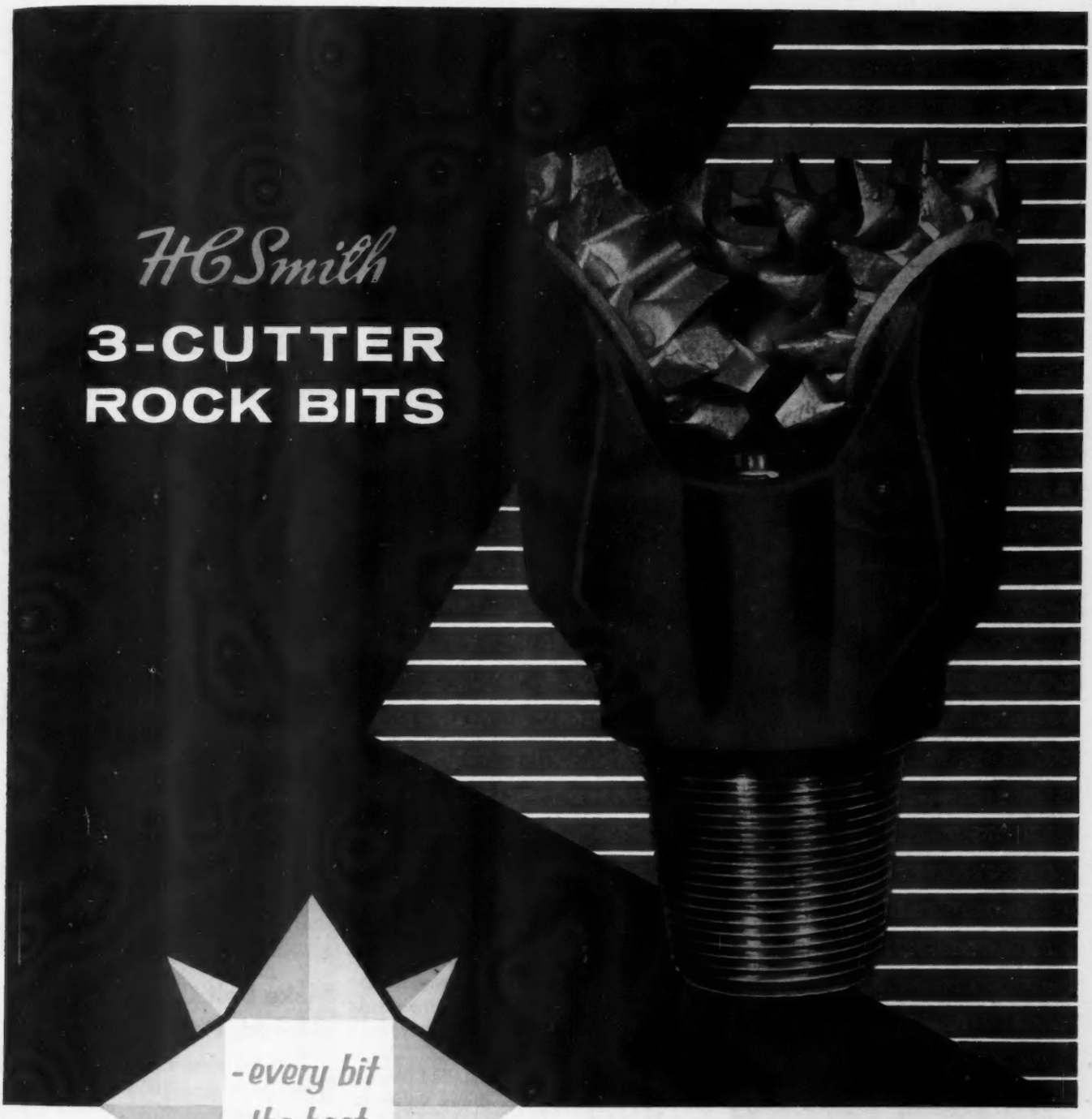
The support shown is constructed of two vertical risers instead of the usual single installation. The vertical sections are connected by short horizontal lengths of scrap pipe conveniently spaced and welded in place.

When the assembly is completed and installed, back pressure valve service work is a simple operation. The horizontal connectors welded between the risers not only increase the strength of the support but also serve as a permanent ladder to the valve located on the end of the vent line.

This manner of construction eliminates the hazards involved in using portable ladders for vent line valve service. The support is also considerably easier to install than one constructed of a single riser.

How-To-Do-It Ideas Earn Money, too!

WORLD OIL editors want how-to-do-it ideas, so your favorite short cut or invention could put money in your pocket! Write down the substance of your latest ideas and send them in with a picture or drawing of the installation . . . if accepted, $10 for each idea will be yours. Send those money-making ideas today to Hints Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas.



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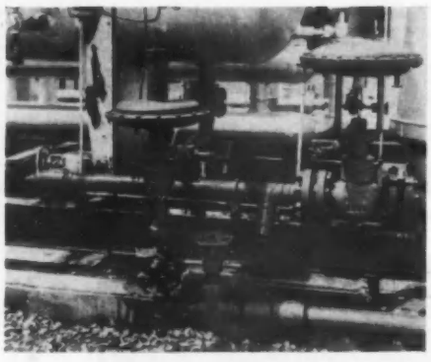
Lifting Eyes Help Substructure Handling

Considerable time is saved and less damage results to the rig substructure when special lifting eyes are welded to the structure at strategic points. An inexpensive, yet highly effective, method employed by one contractor consists in slicing an approximately 45-degree section, lengthwise, from a salvaged drill pipe or tubing collar and welding it, as illustrated, to the side of the substructure.

Several of these, strategically placed so as to assure the load being picked up at the strongest points, greatly simplify loading and unloading of the sections. Such eyes eliminate having to lash wire line slings or chain around any handy beam or cross brace with the probable resultant damage or bending of those important members.

Store Rig Fuel Supply In Compact Compartments

Proper storage of fuel supplies around the rig is very important. One contractor in Canada illustrates the method he has in storing his rig fuel and oil. These oil compartments are very compact and readily accessible. These tanks are shown in the included picture located along one side of the fuel house.



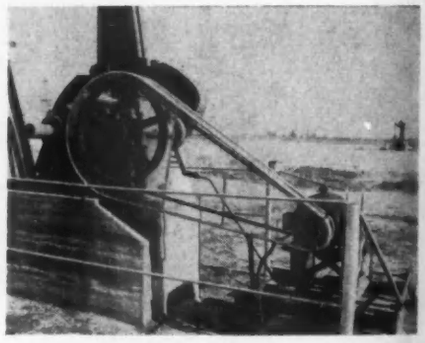
Install Water Check Valve To Regulate Production

Installing a ½-inch valve on the water dump line from a low temperature separation unit can provide an excellent check of water production from gas-condensate wells.

Gas-condensate wells normally produce "sweet" water. Since this water percentage is relatively low, provisions are usually not made to measure produced water in stock tanks or other vessels. The installation shown in the photograph is a simple, economical means of determining accurately this "sweet" water production.

The ½-inch valve is installed downstream from the water dump valve as indicated. The 1-inch valve on the pit line is closed and the ½-inch valve opened. Water is dumped from the separator, through the ½-inch valve and copper tubing into a 5 gallon can. This can is used to measure the water displaced from the low temperature separator in a given period of time. The time required to collect 5 gallons of water is noted and the rate is converted to a daily basis. The converted figure is water production in barrels per day.

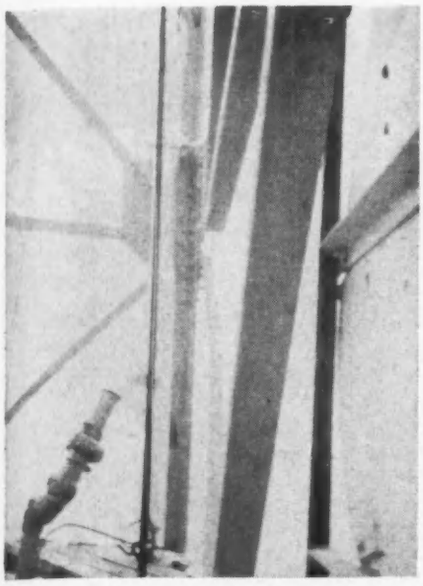
The ½-inch valve is closed and the 1-inch valve opened at the conclusion of the test period. This allows the water again to be dumped directly to the pit.



Make Belt Guard for Pump Of Rod, Hardware Cloth

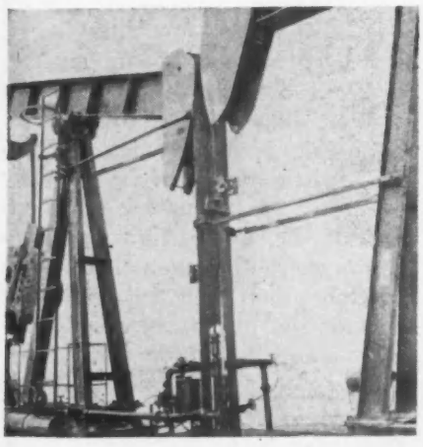
Re-equipping a pumping unit with a different gear box and/or prime mover often requires the fabrication of a new belt guard which will fit the changed conditions and distances between the two sheaves.

Instead of going to the expense in both materials and welder's time to make one of sheet steel, one company finds it desirable to build it of sucker rod material and hardware cloth. Two lengths of sucker rod, providing the framework, are bent to conform to the desired shape around the two sheaves, with small brackets being attached wherever convenient for bolting it to the gear box and motor base. The framework then is wrapped with easily-formed hardware cloth.



Reduce Pump Vibration With Standpipe Assembly

An extension is placed approximately 9 feet on the end of the standpipe. This extension will serve as a air chamber very similar to the ones that are used on most muds. This assembly should minimize or eliminate excessive pump vibration that is normally present in the standpipe.



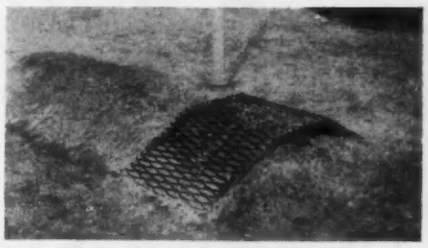
Notched Steel Plate Lends Protection for Polish Rods

There are many instances of damage to polish rods and other surface equipment of dual pumping wells caused by rod strings parting or movement in the pumping unit itself.

Here is a unique method of protecting polish rods and horseheads of this type of installation. A ½-inch by 12-inch steel plate is placed between the two polish rods. The plate is notched at the bottom to fit over the dual tree and other surface producing equipment.

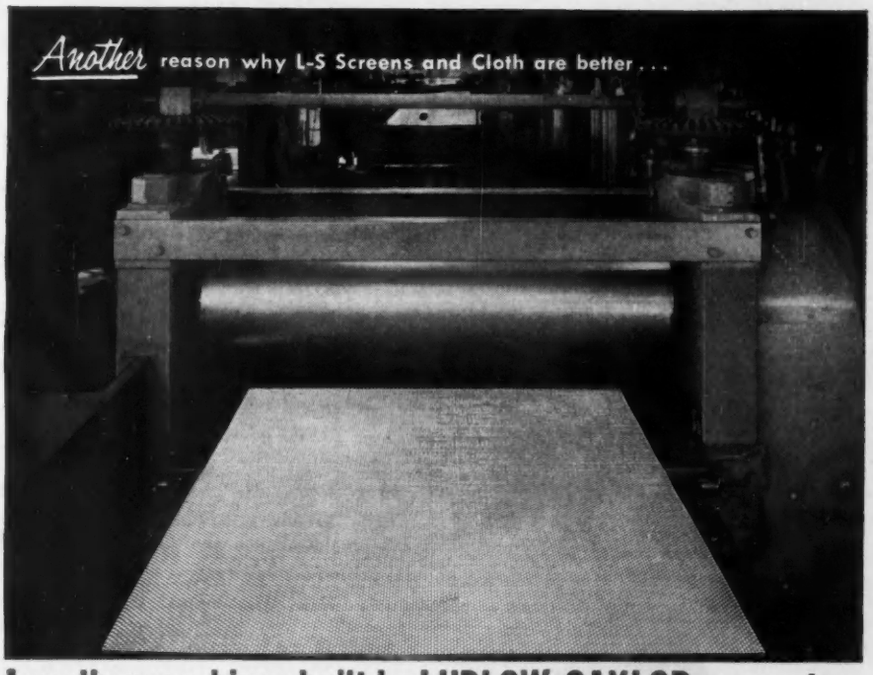
The assembly is retained in a vertical position and kept centered by means of four pieces of angle iron. Any scrap angle iron on hand may be used. Two sections of the bracing are attached to the samson post of each pumping unit as indicated. The braces are bolted into place. A screw adjustment on each piece of the angle iron permits fine adjustment of the protective plate.

The entire device may be easily and quickly removed for rod jobs etc.



Low Cost Prefabricated Ramp Stops Dike Damage

Simplicity of construction and low cost are features of this efficient ramp



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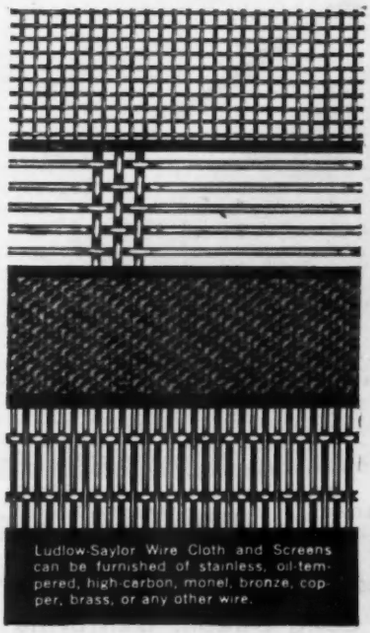
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design to prevent damage to earthen dikes surrounding a tank battery. The basic framework consists of the two sides which are fabricated from 2-inch angle iron. The shape of these is determined by that of the dike itself. Once the side pieces have been assembled, a sheet of heavy expanded metal, an ideal non-skid surface, is tack welded to them and shaped to fit.

Low cost of the ramps make it possible to use more of them at a given location, thus saving extra walking and time and, of prime consideration, encouraging workmen to use the ramps instead of taking "short-cuts" by climbing over, and possibly damaging, the earthen dikes.

By careful matching of the ramp to the dike cross section, much of the weight of a man is absorbed by the dike itself, hence much less structural strength is required in the designing of the unit. Building all dikes on the property to the same general shape and height, simplifies quantity production of the ramps in the shop.

Skid-Mount Electrical Panel To Handle Current Easily

The skid-mounted electrical panel, shown here, is one way of handling the power generated by the power plant on your rig. Well sealed units are mounted in a manner that makes them easy to install and service.

The battery of panels is protected by a sturdy skid with a pipe railing to keep people at a safe distance. Hooks are provided on the top of the unit for lifting it and on the skid ends for pulling. The two clamps and steel base plate on the end of the skid make it an easy job to quickly install the vertical pole. Cables from the panel are run up the pole to a clamp at the top from where they are directed to the various points of the location where a supply of power is required.

This method provides a very neat, practical way of handling a job that often becomes haphazard, resulting in dangerous electrical distribution systems.

Barbed Wire Tie Post Saves Clothes and Skin

This easily installed barbed wire tie post can save torn clothes and prevent possible injury to field personnel. A few minutes welding time is all that is required for a proper installation.

A ½-inch sucker rod is welded to the fence gate post as shown in the photograph. By tying directly to the sucker rod, it is necessary to completely encircle the gate post with the

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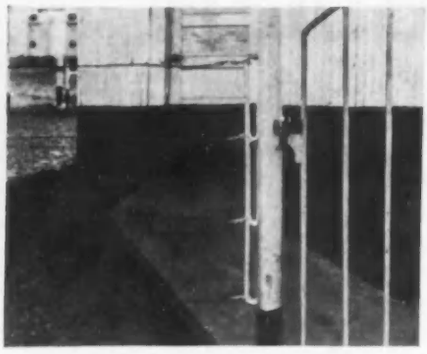
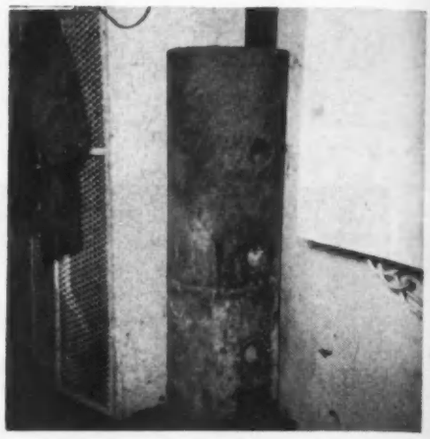


barbed wire. The wire is therefore not directly exposed to personnel using the gate. A neater, quicker wire installation also is obtained by use of this method.

Construct Doghouse Heater From Assorted Scrap Pipe

A good doghouse heater can be made as illustrated from a piece of 24-inch conductor pipe and three



short lengths of smaller diameter pipe. Six holes are cut in the side of the conductor pipe. Three holes are equally spaced apart on each side. The short lengths of pipe are welded into these holes for air convection tubes. Piping gas to the base of this heater and providing a vent into the top completes this inexpensive, neat hot air convection and radiant type heater.

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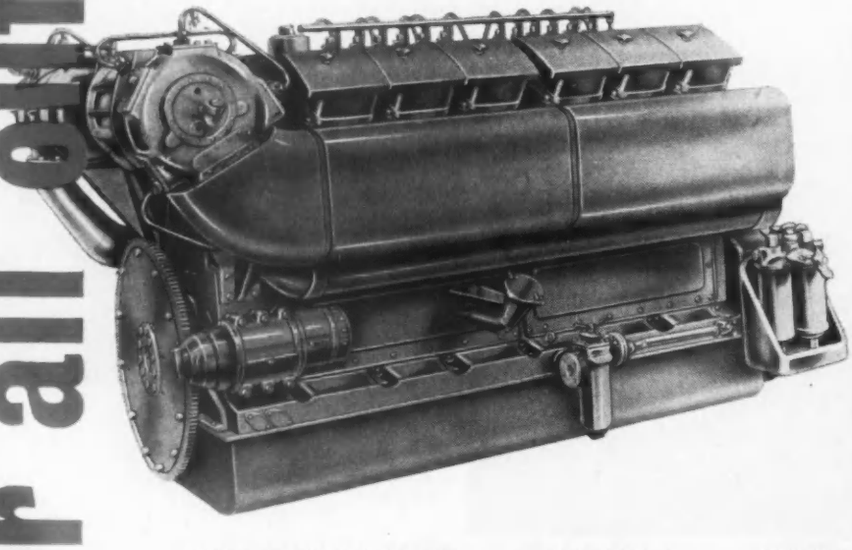

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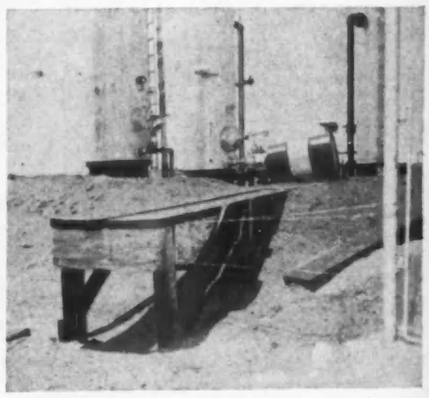

Wooden Platform Serves As Chemical Drum Rack

This easy-to-build platform, constructed of scrap lumber, offers several advantages when a chemical injector pump is situated inside the tank battery firewall. Built to the height of a pickup truck bed for easy unloading, the platform eliminates possible injuries which may result from pushing the heavy drum over the firewall.

Also, it helps keep a clean injection system since chemical does not have to be carried in buckets but flows directly from the drum to the pump. Chemical waste is reduced and time is saved since one man can unload a full drum of chemical. A wooden guard on the firewall end prevents the drum from rolling off the platform.

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Edward Globe Valves

Bodies are drop-forged steel, for greater strength and resistance to erosion. Large-diameter handwheels permit operation without a wrench or cheater; cross-arm Impactor* handle for quick, tight closing is standard on 2" Fig. 158. Figures 158 and 2698 have replaceable seats. Disks—both plug and needle types—are carefully aligned, and seats are lapped for tight sealing. Stems are EValloy,* an exclusive Edward stainless steel, centerless ground to a fine finish. Carefully machined Acme stem threads assure easy operation. Bonnet threads plated by an exclusive EValizing* process for maximum resistance to wear and corrosion. Deep stuffing boxes, with exclusive EValpak* asbestos-graphite packing, assure a tight seal with minimum resistance to stem turning.

Edward Ball Check Valves

Identical to Edward globe stop valves in body and seat features. Rolled steel bonnet with integral ribs to guide ball accurately. Ball is corrosion-resistant high carbon stainless steel, precision-ground for tight seating. High carbon stainless steel spring gives positive aid in seating ball.

Edward Mudwonder Valves

Body and bonnet are high-strength alloy steel with heavy body-bonnet cover flanges. Accurately machined to assure drop-tight sealing under extreme pressures. Double-threaded yoke bushing, completely enclosed, gives 2-to-1 ratio. Corrosion-resistant stainless steel stem with slotted gate coupling to eliminate bending or binding. Gate is hard chrome plated to reduce friction, resist erosion and abrasion. Seat insert of resilient buna–N synthetic rubber, molded integrally over steel wear rings. Seat and gate easily replaced without removing Mudwonder* from line.

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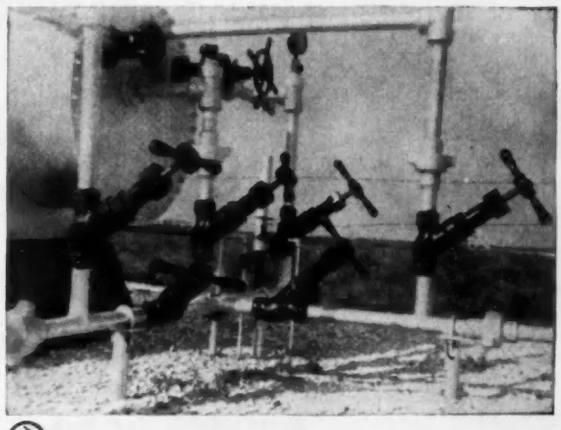
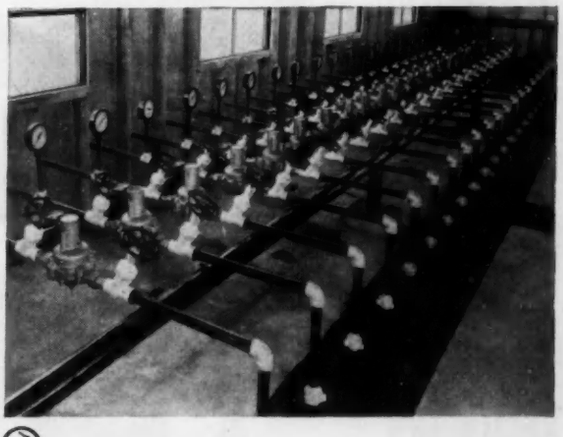


Edward 2" Fig. 158 valves in service on heater by-pass lines in Louisiana oil fields. Note Impactor handles for quick, easy closing against high pressures.

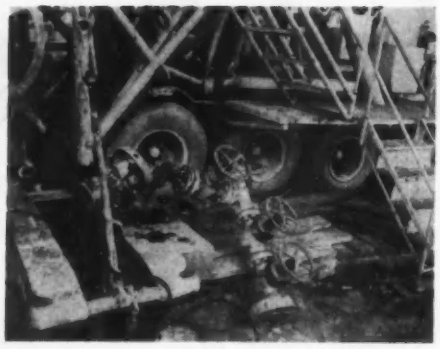
Fig. 2698 valves on cooling coils of natural gas cooler. Scene: New Mexico field processing plant. Lubricated plug valves in photo are Rockwell-Nordstrom.



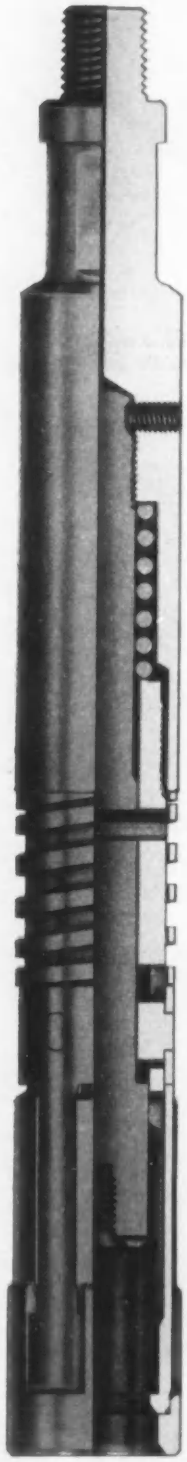
Forty-two Edward forged steel globe valves (Fig. 2698) throttle the flow on this West Texas water flood. Owner reports absolutely *no* maintenance costs in two years (over 4,000,000 barrels of water)!

Extend Bed of Truck To Eliminate Ramp

Instead of backing this rig up onto a ramp, the bed of the truck was extended, and an extra set of wheels were attached to allow sufficient bearing area to park the unit right on the mats. The axle sits on springs which are on an extension of the existing frame of the truck and match the assembly just ahead so that the parts will match in case a leaf is broken in a spring.



With this extra set of wheels, the truck has added bearing area for getting into locations when the roads are soft. At the location, it is simply necessary to put down the regular amount of matting and spot the mast over the wellhead. After the mast is raised and properly blocked, it stabilizes the rig sufficiently that it is not necessary to use extra jacks around the frame of the truck.



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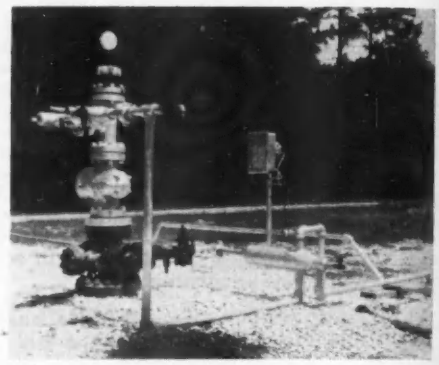


Heat Exchanger Prevents Input Gas Line Freezing

An easily constructed heat exchanger can be used to prevent freezing in input gas lines to gas lift wells.

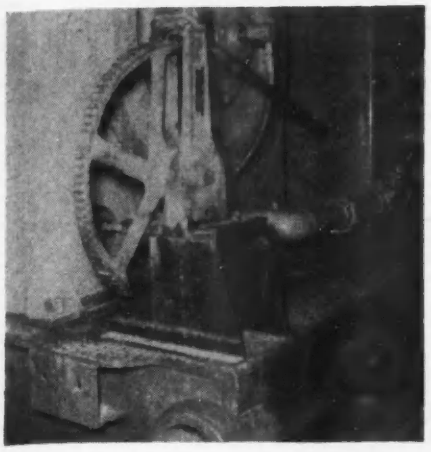
The installation shown is a cheap, simple solution to a sometimes vexing problem.

The photograph illustrates a gas lift well which produces a considerable percentage of hot salt water in addition to oil. The well is on a constant gas injection rate through a positive choke.

A junk piece of 5½-inch or 7-inch casing is orange peeled on each end. Couplings are installed on the top and bottom of the casing as illustrated. A 2-inch tee, choke nipple and additional pipe are centered in the casing. The orange peeled ends of the casing are then welded to the 2-inch insert. This forms a jacket around the choke nipple assembly.

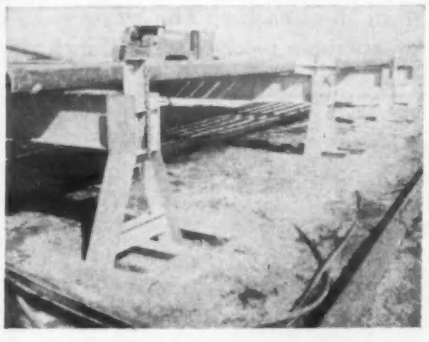
The flow line is connected to the 2-inch couplings. This allows hot well fluid to continually surround the gas line choke nipple. The bull plug shown in the jacket tee may be removed to change the positive choke in the choke nipple.

Heat transfer between the jacket and the choke is sufficient to prevent the gas line from freezing.



Wireline Cutter Is Mounted At Edge of Drawworks Skid

A means for cutting wirelines around a drilling rig is very handy. One contractor in Canada has recently employed a mounted wireline cutter at the edge of the drawworks skid. This mounting is made so that the cutter can be moved for use away from the rig if the necessity arises.



Sheet Steel Stops Hold Pipe on Angle Iron Rack

When pipe racks are made of angle iron as these shown in the picture, a simple stop can be built to keep pipe from rolling off. The stops are made of sheet steel and reinforced by folding over the top and welding a length of steel down the center from the fold to the bottom of the stop.

Small cross bracing is welded about half way down the strip. A short length of chain is welded to the stop and to the rack to keep the stop from being lost during moves or when it is not being used. The stops are mounted on the racks by slipping them into notches cut in the bracing of the rack. The notches are cut to fit the ends of the racks between the end of the horizontal member of the pipe racks and the center piece of the angle iron stands.

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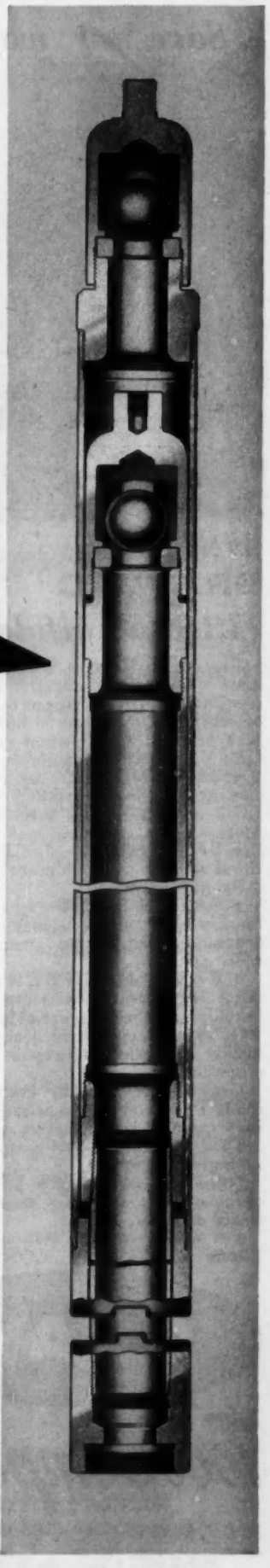

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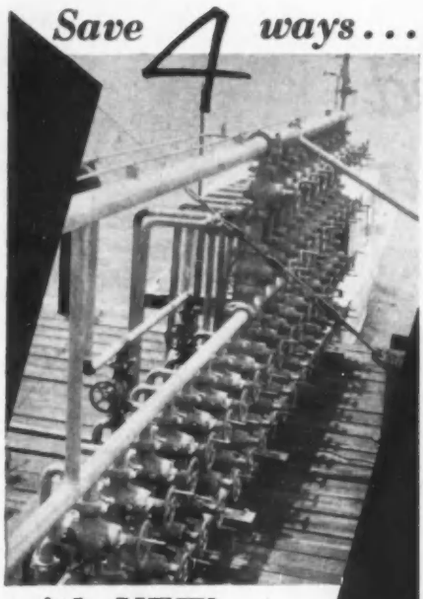

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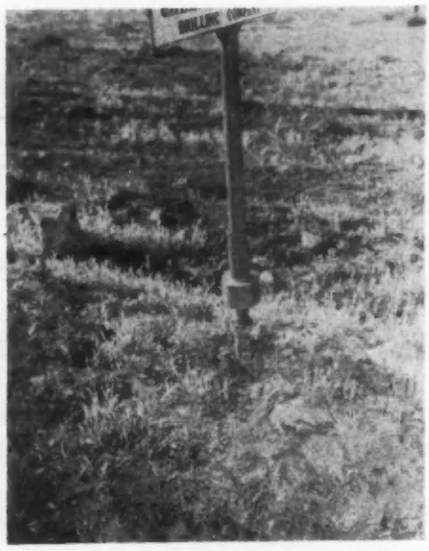


Improved Sleeve Hammer Speeds Erecting of Sign

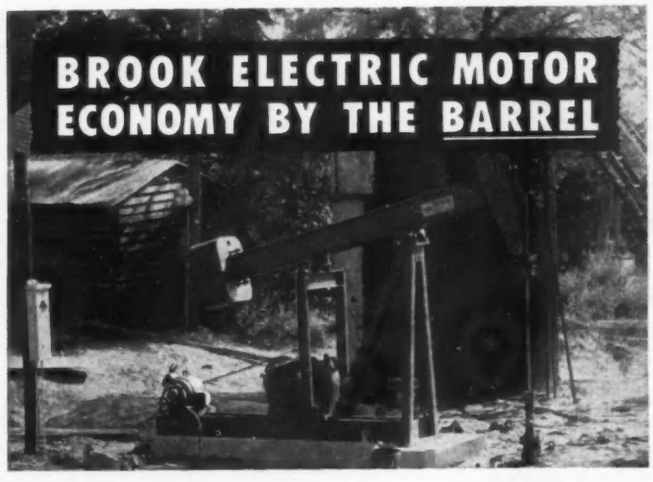
The job of erecting directional signs can be minimized by equipping each unit with a built-in hammer with which to drive the post into the ground without resorting to use of a sledge. Among the types being used is the unit shown which has an unusually efficient and fool-proof driving mechanism.

A light weight piece of pipe, a sleeve having sufficient space to accommodate a man's hand, and to which is attached a heavy cylindrical weight, is slipped over the 2-inch sign post. A heavy stop ring is welded to the post at a point which will be just above ground level when the post is erected and driven to normal depth.

It requires only a few minutes for a man to drive the sign post into the ground with the built-in hammer and the job is done without any damage to the sign itself. Two small vertical vanes welded to the post between the bottom and the stop ring eliminate any chance of the sign being rotated by wind or pranksters once the unit has been pointed in the right direction and driven into the ground.

Simple Housing Protects Fire Extinguishers

A small house built around an outdoors fire extinguisher protects it from the weather. The house is built by sinking a piece of scrap 2-inch pipe



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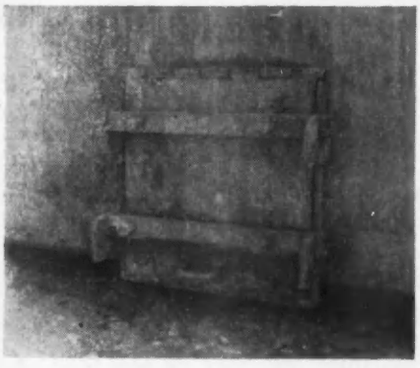
about a foot in the ground. Cement around the pipe for firm foundation. Two pieces of scrap steel are welded to the side of the pipe opposite the approach side. Walls and top of house are made of 1-inch scrap lumber. Back of the box is mounted on the two pieces of steel welded to back of the pipe. The pipe is enclosed in the house. This mounting holds house clear of ground.

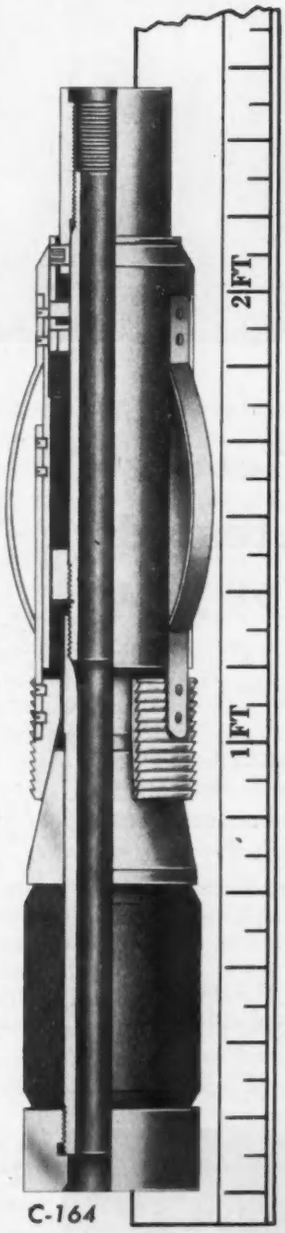
The door must be easy opening and facing in the direction a user would likely approach it. Fire extinguisher is hung from top of the pipe on a hanger welded to the pipe.



Mud Tank Clean Out Gates Are Necessary by Rig

Proper usable mud tank gates for clean out purposes are a "must" on the mud tanks around the drilling rigs. This enclosed photograph shows an example of a design that was used by a contractor in Canada. This mud gate is approximately 2-feet square with a pin-hinge at the top. There are two rectangular bars that recessed into a latching device. When it is necessary to clean out the mud tanks, these bars are lifted off this latching device and the gate is raised. The tanks can then be cleaned out with very little difficulty.

We had to copy



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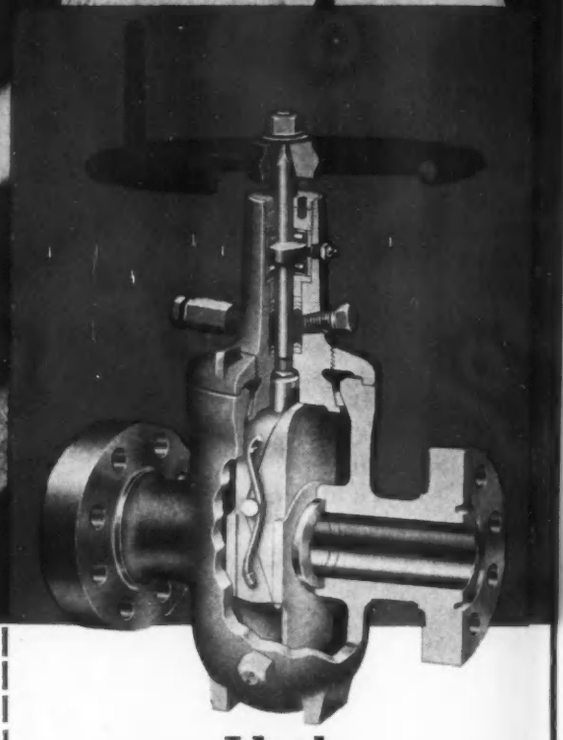

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Long adjustment period awaits . . .

The drilling contractor's future

AAODC president urges contractors to maintain efficiency during low activity period. Customers, suppliers, employes, and competitors influence future, but survival depends on individual fitness

By J. U. Teague,
President AAODC,
Houston

THE ECONOMIC sledgehammer that has richocheted from the oil producer to fall on the drilling contractor is not going to be easy to unburden. As best they can, contractors may as well brace themselves for a long period of adjustment.

An inescapable fact is that there are more rigs available for work than there is work for them to do. This is not news to anybody, but it is a simple statement of what's wrong with the drilling business.

It is highly unlikely that the next few years will see a revival of activity that will bring U. S. totals up to anything like the 1956 peak of 58,400 wells. The professional guessers are now estimating 1958 wells drilled at about 47,500—and even that will require a last-quarter spurt.

Nobody has to tell oil operators of the need to maintain drilling activity at a level adequate to assure supplies to peacetime or emergency markets. Most of the operators I know *want* to drill more wells, but feel that their current income does not justify more than a minimum-necessary drilling program. There are a number of excellent arguments in favor of expanded drilling, but it is hard to dispute the first-half earnings reports.

Rather than rehash the factors that contributed to the slump, it may be more constructive to take a close look at the contractor's present situation, with the idea in mind, "Where do we go from here?"

Despite the honor of being AAODC president, I cannot presume to be spokesman for everybody in the industry. It is as one man's opinion, then, that I will venture a few observations and guesses on the plus and minus factors concerning the drilling business.

There still is some hope. As of this writing, there seems to be a thin, pale light gleaming over the horizon. The shadows are still present, but the outlook is not quite so bleak. Relief is in sight on the problem of burdensome stocks. Most states which regulate oil production have been able to increase allowables, which certainly benefits domestic producers. The general business picture is looking up, if we can use the stock market as an indication. There is a good possibility of a slight rise in consumer demand for oil and gas.

Another factor which ultimately will improve the over-all drilling industry's economic situation is the gradual reduction in number of drilling rigs, to bring supply more in line with demand. This trend should serve to strengthen, rather than weaken, the industry—if we can keep existing rigs efficient and competitive.

The reduction in usable rigs is a fact, but the rate of reduction is difficult to determine. Some rigs have been stacked by contractors waiting out the doldrums. Many older rigs have been retired or cannibalized for replacement parts. There have been few new entries into the contracting business, and the number of firms has been somewhat reduced through mergers or natural attrition. Some drilling contractors have gone broke.

Obviously, these events cannot be looked upon with favor by all contractors, and certainly not by supply companies who are finding a reluctant market. For a while, it looked as though contractors might get some relief from the pressure of high and rising costs. Now we are again faced with increases in the costs of the industry's backbone, steel. And the contractor is unable, in turn, to pass along these imposed higher costs to his customer. Naturally, he is doing some serious soul-searching before he goes on the line for new equipment.

Operators are searching their souls, too. They are listening more attentively to the engineers who advocate wider well spacing. They are expressing great enthusiasm for multiple completions. They are urging more extensive property unitization for field development. These ideas ultimately will have considerable effect on where and how many wells are drilled in the future and are of great economic interest to the drilling contractor.

Two years ago, most of us thought our belts were as tight as they could get—until we punched another eye and hitched them up another inch. Along with the operators, we have found ways to trim a little more ex-

cess fat. We thought we were trim in 1956, but now we're really all muscle. And for the foreseeable future, the lean operating techniques we have painfully learned during this anxious period must necessarily continue to be enforced.

The time is too early, and we are too close to the situation to determine whether the events of the past 18 months are symptoms of a new economic trend having a long-lasting effect on the drilling, producing and supply businesses. It has been our observation that most "economic trends" are determined several years after they happen.

But if it is true that we are in for a long wait before we again hit the 58,000-well mark, then we can only hope that we have learned some valuable lessons during the slump.

Valuable lessons learned. One thing we have learned quite forcibly is that we are far from being "independent" businessmen, although (Thank God) we operate in a free economy. Drilling contractors are dependent for survival upon a number of different groups: customers, suppliers, those with a financial interest in their companies, employes, government agencies—even their competitors.

Without attempting predictions, I would like to offer a few hopes concerning the drilling contractor's future relationships with these groups.

Where customers are concerned, I hope the contractor will continue to maintain the respect he has achieved as a competent specialist. It is a development of recent years, I think, that operators have come to acknowledge the accomplishments of the contractor in learning to make hole twice as fast in 1958 as he could in 1941. Our reward is that contractors drill 93 percent of all wells. The demand for drilling is sluggish now, but operators know they can depend on drilling contractors to rise to the occasion to drill any number of wells they may require. (On this point, I *can* speak for the entire drilling industry in hoping we'll be called on to meet the challenge.)

The most ticklish point in the contractor-operator relationship, of course, is the matter of price. As a customer, the operator is going to shop for the best bargain he can get.

In drilling, as in any other service, the best bargain may or may not be the lowest priced. I believe, and think most producers will agree, that it is to the operator's benefit in the long run to limit bid invitations to contractors who have good equipment and are financially stable. The AAODC membership roster provides a good checklist of contractors who meet these requirements.

In the matter of footage price, it remains the responsibility of the contractor to make up his own bid. The fondest hope I can offer to the industry is that each contractor will bid every job at a price that will enable him to satisfy his creditors and at the same time make a little take-home pay and lay aside some reserve for replacement and depreciation of equipment.

The contractor's financial undoing is sometimes the result of his being overwhelmed by his own efficiency. He acquires new and powerful equipment and evolves better methods that enable him to speed up drilling—then discounts his costs so that he loses the benefits.

Oilfield suppliers have cooperated. Improvement in technical efficiency brings us to another contractor relationship—with suppliers. There is no question that the drilling industry owes a considerable debt to oil field equipment manufacturers and service companies for their contributions, both in technical research and distribution systems.

In short, the drilling business wouldn't be where it is today without the supply industry. We wouldn't be able to drill 20,000-foot holes without the improved bits, drilling muds, power and other equipment developed by the supply industry. We wouldn't be able to operate around-the-clock without the dependable service of oil field suppliers.

We also wouldn't find ourselves in the predicament of having a good many of our rigs stacked today if it were not for the relaxed credit policies of some suppliers who have been so ready to put new people in business. I don't mean to suggest that the supply companies forced anybody to become a drilling contractor. There is always (even now) a long queue of optimistic would-be contractors standing in line for credit. I can only express the hope that when conditions improve the suppliers will carefully examine the financial responsibility of credit applicants and be cautious about putting large numbers of new rigs in the field.

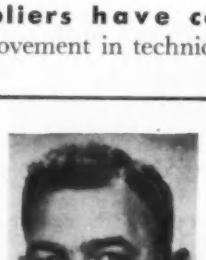
Personnel must be considered. Employes are another category in the contractor's dependency. Even in flush times it is hard to train and hold together skilled personnel. In the present rough times, it is one of the contractor's prime problems.

Oil well drilling is a vital industry. Its vigor is dependent upon its skilled labor force. Contractors are very much concerned about the effects on that force as a result of having to shut down approximately one-third of their rigs. From a peak of approximately 60,000 men two years ago, the U. S. drilling industry now employs about 45,000.

There is a way that we can maintain a skilled corps of drilling personnel, if all contractors will avail themselves of the means. It is my sincere hope that all drilling contractors will take advantage of the training tools placed at their disposal by the AAODC. We can continue to develop key men in our field crews with the aid of the School of Drilling

Continued on Page 165

About the Author



J. U. Teague, president of Columbia Drilling Company, Houston, took office as president of the American Association of Oilwell Drilling Contractors Jan. 1, 1958, for a one-year term. He was elected in October, 1957, at the 17th Annual AAODC meeting in Tulsa. Before his election as AAODC president, Teague was national vice president of the drilling association. He has been active in AAODC work more than a decade, and previously had served as chairman of the Rotary Drilling committee for three years, chairman of the Houston chapter, vice president of the Gulf Coast area and a director.

Teague was graduated from the Rice Institute, Houston, in 1930 with a B.S. degree. He worked for Humble Oil & Refining Company for 10 years as a petroleum engineer, leaving to join Hogg Oil Company. During World War II, he served in the Navy 3½ years. He organized Columbia Drilling Company in 1949.

Here are essentials of . . .

Jet deflection drilling

Conventional jet bits are used in lieu of whipstocks to drill directional wells in the Gulf Coast and offshore areas of Texas and Louisiana. Over-all directional job costs are being reduced considerably through application of the jet technique

By Robert W. Scott, Engineering Editor, WORLD OIL

DRILLING DIRECTIONAL holes by the jet bit method has become a popular, money saving technique. Since the method is limited in use to soft formations, it has been exceptionally well-received in the Gulf Coast and offshore areas of Texas and Louisiana where unconsolidated formations predominate. Countless hours of rig time amounting to thousands of dollars have been saved since the method was introduced by The California Company.

Basically, the technique consists of "kicking-off" or deviating a hole by applying a jet of mud to a specific portion of the bore hole. Standard three cone jet bits are used in the operation. The bit is equipped with the usual three jet nozzles. However, one nozzle is oversize, normally twice the diameter of the remaining jets. Usually, a 7/8- or 3/4-inch nozzle is used in conjunction with two 3/8-inch jets. Other combinations also have been used. (Figure 1.)

Several different combinations of bottom hole assemblies are used. Figure 2 shows some standard hook-ups used by one operator.

After selecting a proper assembly, the bit is lowered to bottom. The large nozzle is oriented in the direction the operator wishes the hole to deviate and the rotary locked in place. A single shot conventional instrument run on wireline generally is used for orientation purposes.

At this point pump speed is increased to a maximum. It is desirable to pump as large a volume of mud as possible. The main flow of mud is directed through the large jet in the bit. Since the jet is pointing in the direction the operator wishes the hole to deviate, a terrific washing action is directed against that portion of the hole.

During this washing period, one operator reciprocates the pipe over a 6-8 foot height. This is to facilitate washing the wall as well as the bottom of the hole (Figure 3). Others may use variations of this technique. One operator, for example, simply picks up the weight of the string (so the bit barely clears bottom) and continues jetting. This procedure appears to work as well as the reciprocating method.

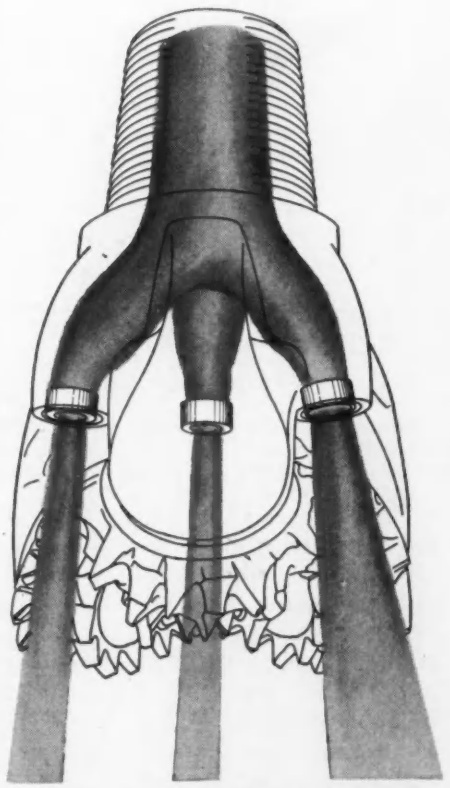


FIGURE 1—This schematic drawing shows the relationship of the jet nozzles used in the jet deflection drilling technique. Note that the nozzle on the right is passing almost twice as much fluid as the remaining two jets. A 7/8-inch or 3/4-inch nozzle usually is used in conjunction with two 3/8-inch nozzles.

After 3-4 feet of hole have been washed, the pipe is lowered to bottom and the rotary unlocked. Pump pressure is reduced at this point so that drilling (and not washing) may proceed in the conventional manner. Drilling then commences in the washed portion of the hole.

Rotary speed will vary depending upon formation characteristics, area etc. Usually, a speed of 50-70 rpm is sufficient to maintain an established course. Bit weight should be carried at a maximum; however, this also is dependent on local conditions.

After drilling approximately 15 feet, the jet nozzle again should be aligned in the proper direction. An additional 2-4 feet of hole is jetted as before. Pipe is reciprocated over a 5-6-foot height during this operation.

The kelly is drilled down following the previously described jetting procedure. A "picture" is taken in the conventional manner. If the desired proportional build-up has been obtained, drilling is resumed. If the build-up is not as desired, additional washing operations are conducted. This procedure is repeated until the desired direction and deviation have been obtained. Drilling then continues in the normal manner.

Once on course, it is recommended that a "picture" be taken after each 180 feet of hole (6 joints) have been drilled. Accurate operations are assured if this procedure is followed. Physical markings are not desirable as a means of orienting the large jet nozzle. The width of a chalk line could cause considerable error, since each small deviation would be additive.

Several distinct advantages of the technique are apparent. They are:

- The over-all time required for a directional drilling operation is reduced considerably. No trips are required to set whipstocks each time a correction in deviation or direction is

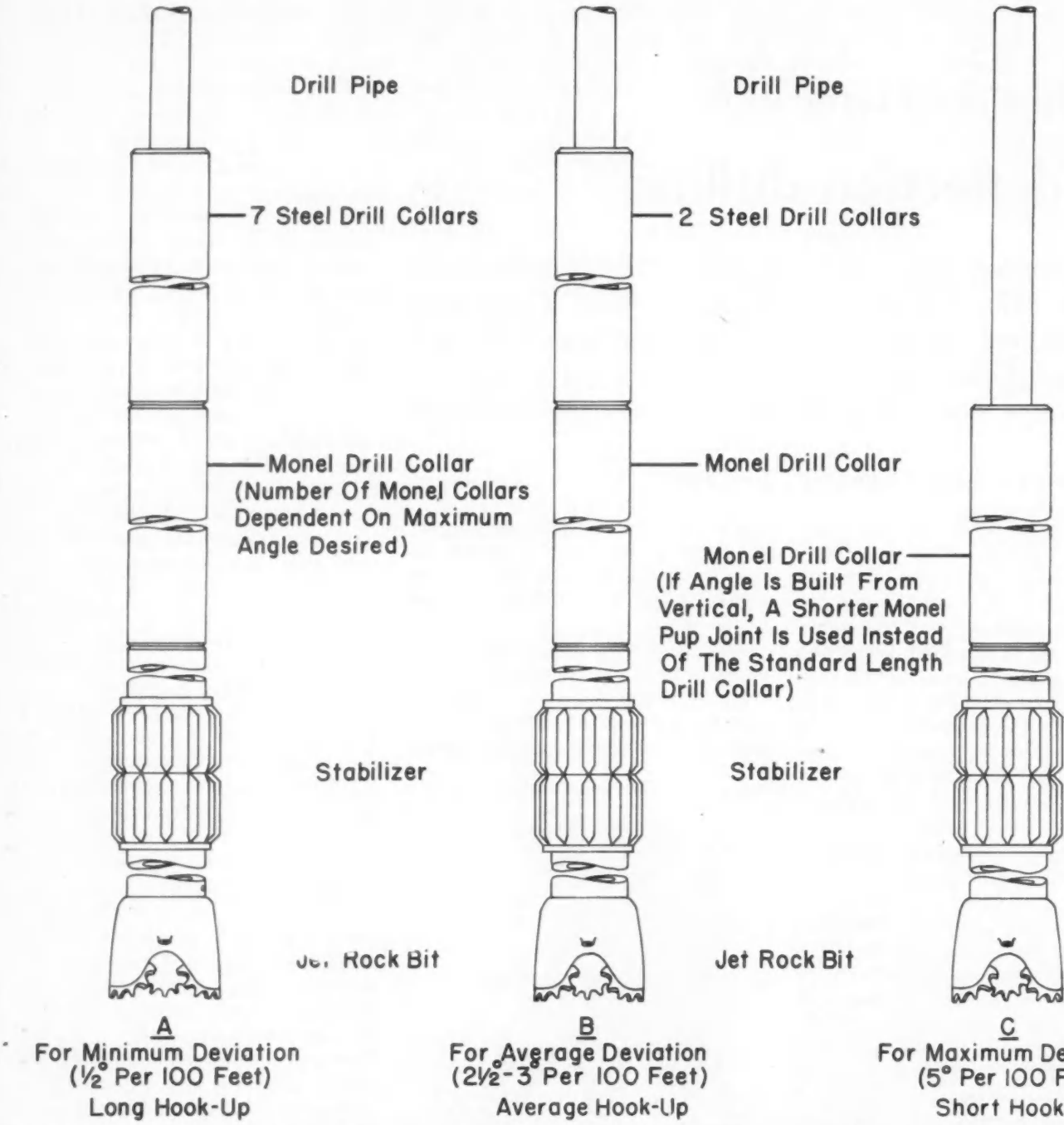


FIGURE 2—Three common bottom hole assemblies used in the jet deflection procedure are illustrated. These are merely average examples since local drilling conditions have a considerable bearing on the proper assembly to be used in a given area. As a rule of thumb, short hook-ups are used for maximum deviations and long hook-ups for minimum deviations.

required. In many cases, the entire surface hole can be directionally drilled with a single bit and no round trips. In one instance, 3,000 feet of hole was drilled in 35 hours at a maximum angle of 11½ degrees. No round trips were required during this period. The resultant saving in rig time which can be obtained with the method can amount to thousands of dollars, especially offshore.

- The "dog-leg" hazard encountered in whipstock operations is relieved. The washing action of the jet method leaves no sharp shoulders in the hole during the initial "kick-off."
- A more gradual deviation can be obtained during the initial "kick-off."

In some instances when very close control has been required, deviations of ½ degree per 100 feet have been maintained. These gradual slopes are not available when using conventional techniques.

- Short bottom hole hook-ups allow the jet method to deviate a hole as much as 5 degrees per 100 feet (Figure 2).

There are several procedures which should be considered carefully when using the jet deflection method, including:

1. The hole should be circulated prior to each connection. Cuttings must be displaced far enough up the hole so that fall-back will not stick the pipe. A rule of thumb is to circulate (at a reduced rate to prevent washing) for twice the length of time required to make a connection. If a connection requires two minutes, the hole should be circulated for no less than four minutes prior to the connection.
2. The hole should be circulated

"clean" prior to taking a "picture" with the directional instrument.

3. Rapid drilling in soft sandy formations increases considerably the sand content of the mud. Frequently, jet nozzles (especially larger sizes) are cut out in relatively short periods of time. In this case, bit life is shortened even though cutting edges are not worn out. Bit companies are making efforts to correct this erosional problem. One example is shown in Figure 4. Other companies are directing efforts toward reducing fluid velocities through the large nozzle.

De-sanders can pay off under such conditions and are recommended when using the jet deflection method.

4. Hard formations prevent use of the jet technique. Generally, formations which drill less than 50 feet per hour are considered "hard." It is uneconomical to attempt the method in these formations for any length of time. Conventional side-tracking procedures are applicable when such formations are encountered.

To date, the procedure has been used successfully as deep as 6,500 feet. Due to increasing formation hardness below this depth, conventional whipstocks are more feasible than the jet method. The area concerned will dictate the maximum economical depth at which the method is applicable.

Hole size also is an important consideration. Holes as large as 15 inches have been jetted successfully. In many cases, smaller size bits have been used in holes where larger bits would not perform. The technique has been used with 8⅝, 9⅞, 12¼ and 15-inch bits.

Directional people feel that the washing operation could be speeded up if the large nozzle were directed more toward the side of the hole. With this in mind, one bit manufacturer has produced special nozzles for the method. A ⅞-inch nozzle is bored at a 3 degree angle from the vertical. This tends to increase the side-wise washing action and to decrease the time required for jetting.

Although the technique is relatively new, it is in widespread use by many operators. Economic advantages of the method are clear, especially in offshore areas where deviated holes and high rig costs predominate.

ACKNOWLEDGMENT

The author wishes to thank Johnny Cochran, president, Cochran-Dean Directional Drilling Company for his many helpful suggestions concerning the jet deflection drilling method.

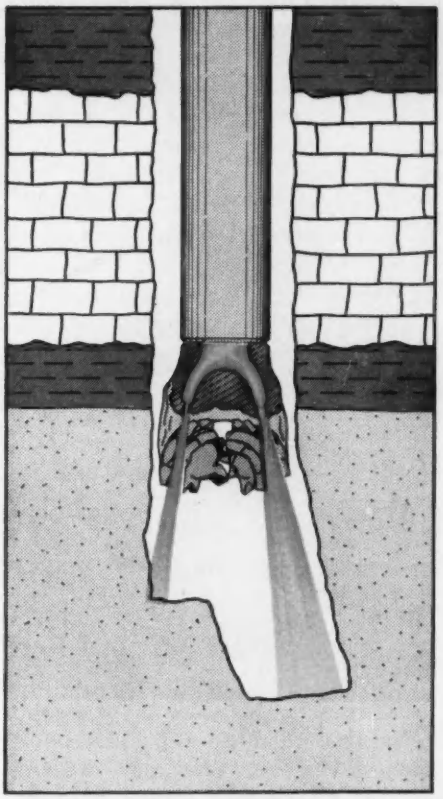


FIGURE 3—A concentrated stream of mud is directed through the enlarged jet toward the pre-determined section of hole. This intense flow of mud tends to wash-out that portion of hole as shown. A single shot directional instrument normally is used for control of the procedure.

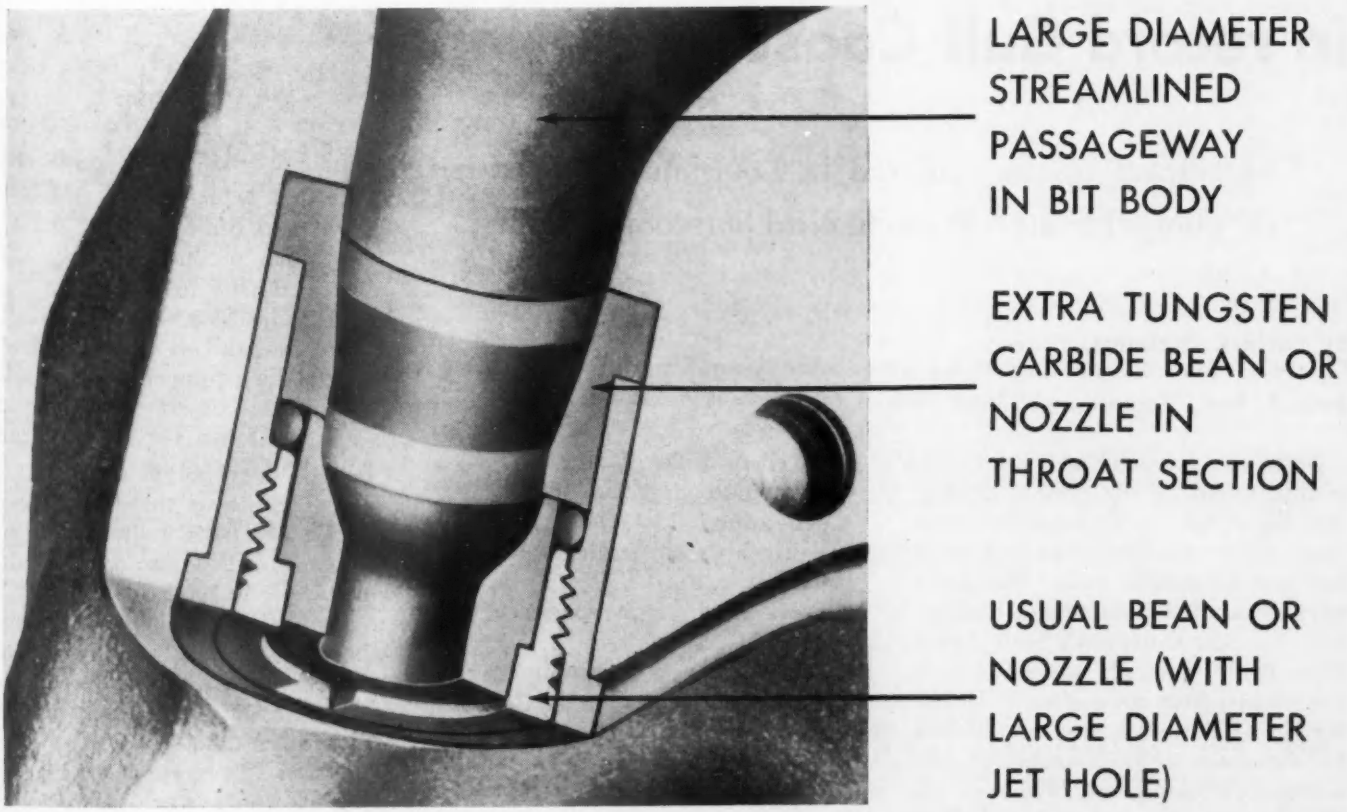

LARGE DIAMETER STREAMLINED PASSAGEWAY IN BIT BODY
EXTRA TUNGSTEN CARBIDE BEAN OR NOZZLE IN THROAT SECTION
USUAL BEAN OR NOZZLE (WITH LARGE DIAMETER JET HOLE)

FIGURE 4—The nozzle combinations used in jet directional drilling direct the drilling fluid at the bit so that most of the fluid volume flows through the leading nozzle which is oriented in a desired direction. This large volume through a single jet nozzle has resulted in the loss of nozzles and heavy washing in the body of the bit. To eliminate bit failures due to this washing action, the modification illustrated has been developed by one bit manufacturer. Tungsten carbide sleeves are utilized above the nozzle proper. This extremely hard material prevents washing action for a considerably longer period of time than the steel which composes the body of the bit.

A DRILLING PROGRESS FEATURE

Gracey-Hellums rig (left) on location in the Caillou Island area of Terrebonne Parish, Louisiana.

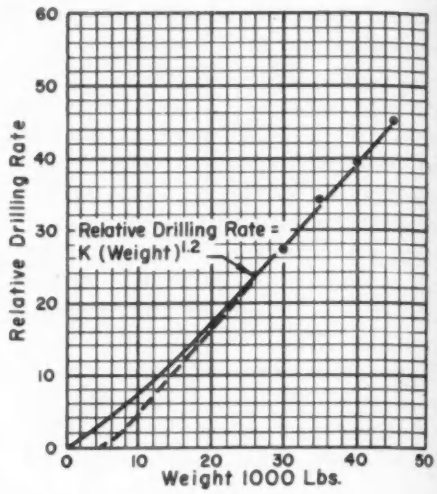


FIGURE 1—Drilling rate compared to weight on bit.

Contractor finds . . .

Efficient drilling practices pay off in record Gulf Coast operations

Significant results achieved in Louisiana wells with rig pumps having 850 mechanical horsepower ratings.

By Earle C. Hellums, President
Gracey-Hellums Corporation, Houston
Jack F. Earl, Engineering Editor, WORLD OIL

WITHOUT the use of additional crew members and during normal drilling operations, Gracey-Hellums Corporation has set new time records in drilling two Louisiana wells. The wells were Union Oil Company of California—L.L.&E. Company's State Lease 2826 Well 14, which was a 9⅞-inch hole drilled from the surface to 13,778 feet in 14 days, 3 hours; and Union Oil Company of California—L.L.&E. Company's State Lease 2826 Well 15, which was a 12¼-inch hole drilled to 12,500 feet in 12 days, 5½ hours.

These factors made this record possible:

- High rotary rpm
- Excellent drilling hydraulics
- Good mud characteristics for fast penetration
- Fairly high bit loading for Gulf Coast
- Previous drilling experience in the field
- Drilling crew cooperation

The wells were drilled in the Caillou Island area of Terrebonne Parish, Louisiana. The area has the reputation among drilling men for "snowbank drilling." Even so, no other well had been drilled in this area approaching the time established by the Gracey-Hellums Corporation.

There were two depth objectives in the drilling prognosis of the two wells:

1. Well 14, which was a 9⅞-inch hole, was drilled to 13,778 feet. A 7-inch production string was set at 13,765 feet.
2. Well 15, which was a 12¼-inch hole, was drilled to 12,500 feet. A 9⅝-inch protective string was set at this depth. Drilling continued ahead to a projected depth of 17,000 feet.

Table 1 illustrates the drilling time breakdown for both wells. The average footage drilled per day for the 9⅞-inch hole to total depth was 975 feet. The 12¼-inch hole was drilled at the rate of 1,022 feet per day. These rates resulted from applying a large percentage of total hole time to actual drilling time. The percentages ranged from 62 percent for the 12¼-inch hole to 66 percent for the 9⅞-inch hole.

Drilling equipment and procedures. Gracey-Hellums Rig 3 is a 20,000-foot diesel-powered inland

drill barge equipped with an 18-inch slush pump (rated at 850 mechanical input horsepower), a 16-inch slush pump (rated at 700 mechanical input horsepower), and a 12-inch mud mixing pump. The drawworks and pump power is supplied from three 520-horsepower diesel engines while the rotary is separately driven with a 330-horsepower engine.

All the hydraulic knowledge presently known was applied to the rig circulating system. Certain equipment limits were set to stay within an economical operational range. A surface pump pressure for the 850-horsepower pump was set at 2,000 psi. The contractor felt that if this pressure were exceeded, additional pump, swivel, and other repair costs would more than overbalance any improvement in drilling performance. Consequently, a hydraulic program was designed within these limits.

In both surface holes, the 18-inch and 16-inch pumps were used in parallel. This allowed a maximum circulation rate for fast "top hole" drilling. A depth of approximately 800 feet was reached before the two pumps were placed into operation. This procedure was necessary because of possible loss of circulation above this depth. If both pumps were used while drilling through this zone, mud returns would most likely be lost. When running 13⅜-inch surface casing, it is common practice for Gracey-Hellums to drill a 12¼-inch hole and then ream to 17½ inches. This practice, in comparison to drilling a 17½-inch hole, has proved to be as fast and also results in a hole which is straighter and in better condition for running 13⅜-inch surface casing.

The 18-inch pump was used below the surface casing. Five-inch drill pipe was used with 103 feet of 7¾-inch by 2⅞-inch drill collars and 280 feet of 6¾-inch by 2⅞-inch drill collars, a total of 383 feet of drill collars.

Field tests indicate that the drilling rate is proportional to the weight on the bit and the rpm of the bit. The

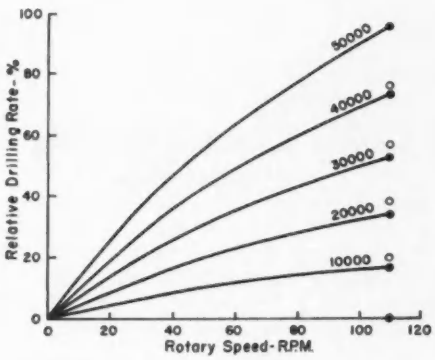


FIGURE 2—Drilling rate compared to rpm of bit.

American Association of Oil Well Drilling Contractors has conducted several tests in West Texas showing these respective relationships (See Figures 1 and 2). Although these tests were conducted in a hard formation area, a similar relationship also is thought to be applicable in areas of relative soft drilling.

The number and size of drill collars are limited when desiring high rotary speeds (See Tables 2 and 3) of the magnitude used while drilling the two wells in Caillou Island area. Also, a common practice within the drilling industry is that bit weight should never exceed drill collar weight.

Realizing these factors, Gracey-Hellums at all times maintains operations as close as possible to these maximum limitations; however, at times it was worth a calculated risk to temporarily exceed such weights to drill hard laminated sections. Rotary speed varied from 300-350 rpm in the 9⅞-inch hole down to 7,500 feet. The speed then was decreased to 200 rpm to approximately 11,000 feet. From this depth to total depth, rotary speed ranged from 150 to 100 rpm. The bit weight varied from 35,000-60,000 pounds down to 9,500 feet, and then decreased to 35,000 pounds to 12,000 feet. Throughout the remainder of the hole, a weight of 25,000 pounds was used.

The 12¼-inch hole differed in that a rotary speed of 300 rpm was maintained to a depth of approximately 9,200 feet. Also, a higher speed of 175-200 rpm was used to a total depth of 12,500 feet, rather than the rpm used on the 9⅞-inch hole. A varying weight of 30,000-60,000 pounds was maintained throughout the 12¼-inch hole.

Amount of horsepower needed. Will an 850-horsepower pump adequately handle these hydraulic drilling requirements? The contractor has proved that it will by the drilling performance obtained while drilling the two wells in record time.

In the contractor's opinion, if the maximum limits set were exceeded, an uneconomical factor and an additional risk would present itself. That

TABLE 1—Drilling Time Breakdown

9⅞-inch Hole

Interval	Casing Program	Mud Weight	Bits	Drilling Hours	Trip Hours	Survey Hole Hours	Csg., Cem. & Nipple Up Hours	Circ. Hours	Test BOP, Repairs Cut Off Drl. line	Total Hours	Total Days
0-13,788	16"-102' 10¾"-2425	9.7-10.8	1-15" 19-9⅞"	200½	85	11	30	2½	10	339	14 Days 3 Hours
Time Breakdown-Percent				59.6%	24.1%	3.4%	9.2%	.8%	2.9%		
Time Breakdown-Percent (Less Casing Time)				65.7%	26.6%	3.7%		.8%	3.2%		

Average Footage/Day 975.4' Average Footage/Drlg. Hour 68.7'

12¼-inch Hole

Interval	Casing Program	Mud Weight	Bits	Drilling Hours	Trip Hours	Survey Hole Hours	Csg., Cem. & Nipple Up Hours	Circ. Hours	Test BOP, Repairs Cut Off Drl. line	Total Hours	Total Days
0-12,500	20"-149' 13⅜"-1825	9.8-10.0	1-22½" 1-17½" 14-12¼"	155	70	8½	42	7½	10½	293	12 Days 5½ Hours
Time Breakdown-Percent				52.8%	23.9%	2.9%	14.3%	2.5%	3.6%		
Time Breakdown-Percent (Less Casing Time)				61.6%	27.8%	3.4%		3.0%	4.2%		

Average Footage/Day 1,022' Average Footage/Drlg. Hours 80.7'

TABLE 2—Drilling Statistics
9 7/8-inch Hole

					OBSERVED DATA								HYDRAULIC DATA						
Bit No.	Bit Size	Jet-J Reg-R	Watercourses No.	Watercourses Size	Depth Out	Footage	Hrs. Drld.	Feet Per Hour	Bit Weight 1,000#	Table RPM	Mud Wt.	Mud Vis.	Pump Operation	Total GPM	Pump Press.	Nozzle Vel.	Ann. Vel.	Hyd. HP	Bit Hyd. HP
1	15"	J	3	5/8"	2425	2425	11½	211	10–20	250	9.9	32	S&P	1147	1600	395	140	1070	916
2	9 7/8"	J	2	9/16"	5691	3266	14½	225	35	350	9.9	35	S	600	1800	386	202	630	443
3	9 7/8"	J	2	9/16"	7503	1812	15	120.7	35–40	300	10	34	S	600	1800	386	202	630	443
4	9 7/8"	J	3	1/2"	8570	1067	12	89	35	275	9.9	33	S	600	1800	327	202	630	320
5	9 7/8"	J	3	1/2"	9532	962	11½	83.7	35–60	250	9.6	32	S	600	1800	327	202	630	320
6	9 7/8"	J	3	7/16"	10318	786	11	71.5	35	250	9.6	34	S	500	1700	352	168	495	313
7	9 7/8"	J	3	7/16"	10500	182	3	60.7	35	200	9.8	49	S	498	1800	350	167	523	312
	9 7/8"	J	3	7/16"	11066	566	11	51.5	35	200	9.8	49	S	498	1900	350	167	552	312
8	9 7/8"	J	3	7/16"	11516	450	13	34.6	35	150	10	47	S	490	1900	345	164	543	292
9	9 7/8"	J	3	7/16"	12038	522	15	34.8	35	150	10.1	55	S	490	1950	345	164	556	292
10	9 7/8"	J	3	7/16"	12370	332	14	23.7	35	125	10.4	59	S	490	1950	345	164	556	292
11	9 7/8"	J	3	7/16"	12661	291	14½	20.1	25	100	10.5	57	S	490	1950	345	164	556	292
12	9 7/8"	J	3	7/16"	12979	318	15	21.2	25	100	10.7	58	S	490	1950	345	164	556	292
13	9 7/8"	J	3	7/16"	13337	358	16½	21.7	25	100	10.8	50	S	490	2000	345	164	571	292
14	9 7/8"	J	3	7/16"	13630	293	16	18.3	25	100	10.8	47	S	472	2000	330	158	550	267
15	9 7/8"	J	3	7/16"	13778	148	7	21.1	25	100	10.8	48	S	472	2000	330	158	550	267

TABLE 3—Drilling Statistics
12 1/4-inch Hole

					OBSERVED DATA								HYDRAULIC DATA						
Bit No.	Bit Size	Jet-J Reg-R	Watercourses No.	Watercourses Size	Depth Out	Footage	Hrs. Drld.	Feet Per Hour	Bit Weight 1,000#	Table RPM	Mud Wt.	Mud Vis.	Pump Operation	Total GPM	Pump Press.	Nozzle Vel.	Ann. Vel.	Hyd. HP	Bit Hyd. HP
1	22½"	R			151	151	1	151		40					100				
2	12¼"	J	3	5/8"	1825	1674	4	418.5	0–5	300	9.8	32	S&P	1117	1500	387	218	978	847
3	17½"	J	4	5/8"	1825	1674	3½	478.0	10	200	9.8	38	S&P	1178	1200	307	100	825	549
4	12¼"	J	2	9/16"	5431	3606	16½	219.0	20–40	350	9.8	32	S	600	1800	386	117	630	443
5	12¼"	J	2	9/16"	7553	2122	16	132.4	45–60	300	9.8	30	S	587	1900	377	115	651	414
6	12¼"	J	2	9/16"	7974	421	4½	93.5	45–60	300	9.9	30	S	587	1900	377	115	651	414
7	12¼"	J	3	1/2"	8573	599	9	66.7	20–50	275	9.8	35	S	600	1700	327	117	595	320
8	12¼"	J	3	1/2"	9258	685	11	62.2	30–60	300	9.9	37	S	600	1800	327	117	630	320
9	12¼"	J	3	1/2"	9854	596	10	59.6	20–60	275	9.9	37	S	600	1800	327	117	630	320
10	12¼"	J	3	1/2"	10322	468	11	42.6	45–60	200	9.8	38	S	600	1800	327	117	630	320
11	12¼"	J	3	1/2"	10789	467	12	38.9	30–60	200	9.8	38	S	587	1800	320	115	616	302
12	12¼"	J	3	1/2"	11324	535	13½	39.6	35–60	180	9.8	40	S	587	1900	320	115	651	302
13	12¼"	J	3	1/2"	11781	457	13	35.2	30–60	175	9.8	49	S	587	1900	320	115	651	302
14	12¼"	J	3	1/2"	12159	378	14½	26.1	30–60	175	10	58	S	587	1900	320	115	651	302
15	12¼"	J	3	1/2"	12342	183	10	18.3	30–60	175	10.1	53	S	587	1900	320	115	651	302
16	12¼"	J	3	1/2"	12500	158	5½	28.7	30–60	200	10.2	58	S	587	2000	320	115	700	302

is, if more drill collars were run so more bit weight could be used, the rotary speed then would have to be decreased. If the same rotary speeds were maintained with an increase in drill collars and bit weights, possible fishing jobs might result. With these practices, maximum performance was obtained with the best combination of drilling techniques.

Also, in view of the fast penetration rates and lack of hole difficulties, it was felt that any additional hydraulic horsepower would not be a feasible expenditure for improving drilling practices in the area.

This does not mean that higher horsepower pumps could not possibly be justified in other areas of operations or where other conditions exists within this area. However, when drilling in an area with similar conditions, pumps in the 850 horsepower range apparently are adequate.

Other factors influencing performance. Although proper equipment and improved drilling practices were important, there were several additonal tangible and intangible factors which played important roles in maintaining an over-all efficient operation. They were:

- Good mud characteristics for fast penetration.
- Good hole conditions including the maintaining of straight hole; no sloughing or tight hole; no drill pipe or bit trouble.
- Previous experience in area of operation.

A salt-water base mud was used down to a depth of approximately 9,000 feet. The mud properties were:

- Mud weight—9.8 to 9.9
- Viscosity—32 to 35 cps
- Salinity—10,000 to 25,000 ppm
- Water loss—50 to 35 ccs

At 9,000 feet, fresh water and chemicals were added to the mud. The weight was allowed to increase gradually to a maximum mud weight of 10.8 pounds per cubic foot at 13,778 feet in the 9⅞-inch hole and 10.2 pounds per cubic foot in the 12¼-inch hole at 12,500 foot. Diesel oil was added to the mud in both holes at approximately 10,000 feet to help maintain a fast penetration rate which normally at this depth begins to slow up due to a lithology change, a decrease in the water loss of the mud, and a slight increase in the mud viscosity.

Field drilling experience. Gracey-Hellums has drilled several wells in the area, thus enabling the corporation to design bit and drilling programs from past experience.

Maintaining good hole conditions, and preventing problems such as sloughing shale, tight hole and deviation difficulties are based on past experience, knowledge of the drilling history of a particular area, close supervision and designing of adequate mud programs.

Rig personnel. A significant share of Gracey-Hellums record drilling operations was credited to the cooperation and efforts of the crews, drillers and toolpushers without which the most modern drilling equipment and techniques could not function satisfactorily.

The practices used in the drilling of these wells have an application to any size of rig. Benefits can be derived by rigs, regardless of size, if all the known drilling practices are utilized efficiently. —**The End**

PART 4: SUPERCHARGING

Know your mud pump—it can save you money

Higher speeds, greater efficiency, smoother operation, and longer parts life result from charging the suction pipe

By Samuel L. Collier and N. B. Heaps
Mission Manufacturing Company, Houston

ONE OF THE most successful methods of correcting mud pump suction problems is the use of centrifugal pumps as boosters (superchargers or prechargers). The addition of a supercharger offers many advantages: elimination of shock loads, smoother operation, increased bearing life and higher speed operation. The supercharger also enables the slush pump to handle gas cut or aerated mud, giving better filling characteristics with less chance of loosing prime.

These advantages can be obtained economically because of the simplicity and flexibility of the supercharger. The pump can be located on the mud pump skid and driven by the same engine. Better results can be obtained by using a separate driver and skid for the supercharger and locating it at the end of the suction line as close to the pit as possible.

Results of field tests show that many operators have benefited from the use of a supercharger. Before discussing actual installations, advantages and limitations of a supercharger and methods of selecting a particular charger for a given job should be well understood.

The second article of this series (WORLD OIL, Aug. 1, 1958, Page 81) discussed the factors involved in suction pipe design that must be considered to obtain normal mud pump operation. These included vapor pressure, velocity head, friction, acceleration demand and pressure drop into the pump. It also showed that the absolute pressure available must equal the total of these quantities to prevent cavitation, or separation, and the resultant shock and vibration of the pump and piping.

If the total pressure available is insufficient for these requirements, the effective pressure can be increased by the use of a supercharger in the suction line. Best results will be obtained only by a consideration of the complete problem. Field operation was duplicated carefully in a laboratory where it was possible to make a large number of variations in operating conditions. This included tests of many types of supercharging pumps in conjunction with a wide range of mud pump operation (different liner size, valve type, pump speed, pressure and mud characteristics). Data were carefully measured by electronic pickups and recorded by a highly responsive light beam oscillograph on a photographic film. These records made a detailed study of the problem possible for the first time.

During normal operation, the pressure in the suction of a mud pump varies as shown by the oscillograph record of the suction pressure (gage) measured at the mud pump suction flange (Figure 18). In this case the pump was operating at 60 spm with 5½-inch liners and a 14-inch stroke. Suction was from a tank 25 feet from the pump with the mud level about 4 feet above the mud pump suction centerline.

Notice the vacuum of 10 psig produced in the middle of the mud pump

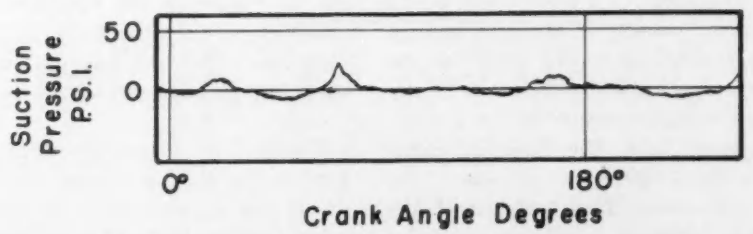


FIGURE 18—Normally the suction is under a vacuum for large portion of the string.

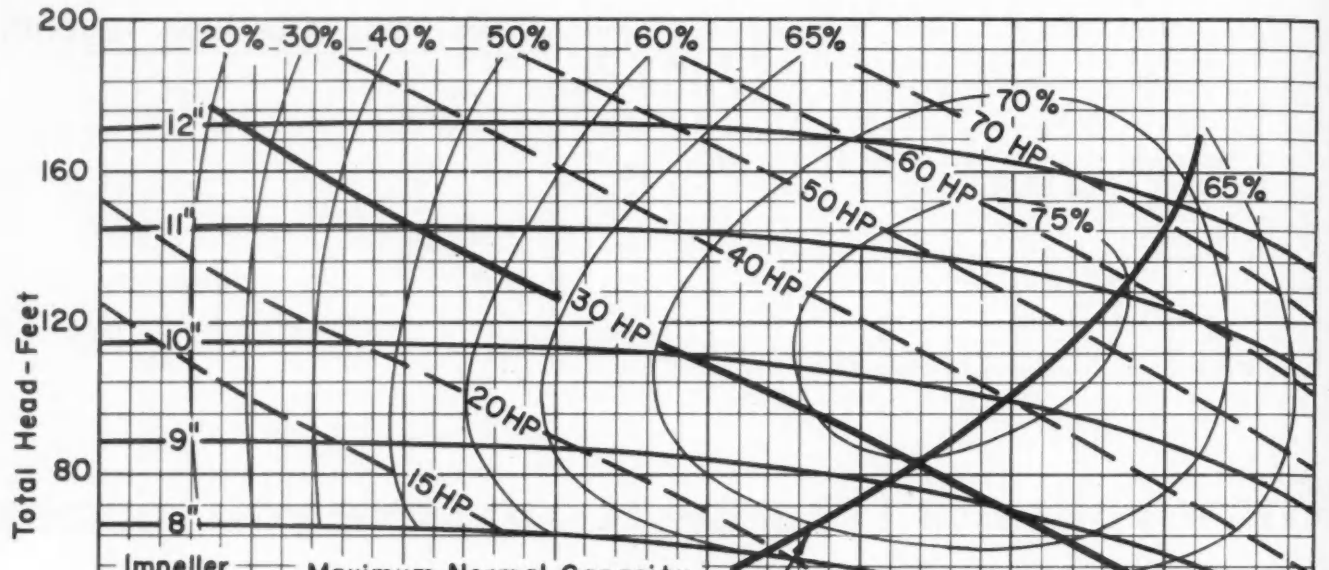


FIGURE 19—Standard curves are for steady operation and do not show accelerating ability.

stroke and the surge that rises to 27 psig at the end of each stroke. At the beginning of a stroke, the mud must be accelerated; the piston pulls away from the mud and produces enough vacuum so that atmospheric pressure pushes the mud into the mud pump. As long as the piston velocity is increasing (which happens up to mid-stroke) the suction pressure falls, thus producing the large vacuum at mid-stroke. When the piston begins to slow down, the mud which is flowing at a high speed begins to push against the piston. This causes the suction pressure to rise again reaching a maximum at the end of the stroke when the piston comes to a stop.

This is the normal surge pattern into which the supercharger must pump. Figure 18 shows the time scale for these surges. The pressure varies continuously and rapidly. This is an unusual system for a centrifugal pump to handle, usually it operates against steady conditions at one point on the performance curve, as shown in Figure 19. As the back pressure on the centrifugal pump falls, the flow increases; as the back pressure increases, the flow decreases. The surge and the piston velocity thus will cause a variable demand, and as the operating point for the supercharging pump moves back and forth, the pressure varies accordingly. The pump must be designed for this operation. It must be able to accelerate the flow as fast as the piston is accelerated at the start of a stroke. It must respond rapidly so the flow rate not only matches the piston rate at mid-stroke, but also exceeds it enough to push on the piston and thus prevent the occurrence of the vacuum.

A careful study of the effects of this operation in the centrifugal pump is important. This operation affects the type of pump design, its operating speed, bending of the centrifugal pump shaft in the packing area, bearing loading, wear and cavitation in the supercharger. A pump that is entirely satisfactory for a steady flow could give packing, bearing and cavitation difficulties in this type of service. In Figure 20 the displacement or vibration of the charger shaft is being recorded electronically along with other measurements on the duplex pump.

Figure 21a shows the suction pressure, at the mud pump suction flange, when the supercharger is unable to produce the high flow required at mid-stroke. The vacuum produced by the high piston speed is not eliminated, and additional surging develops because the pump acceleration is too low. Figure 21b shows a more satisfactory matching in which the vacuum has been eliminated and the surging is reduced to the normal effect expected due to the variation in piston velocity. In this case, a larger impeller with adequate accelerating ability has been used to obtain satisfactory operation.

Advantages. Tests prove that the use of a supercharger offers real advantages. Generally, mud pumps that were operating with severe knocking conditions were corrected when the supercharger was started. The elimition of the knock resulted in smoother operation. Smooth operation in this case is a result of the removal of a double stress reversal in all fluid end parts when knock occurs. It also is evident in the increased steadiness of the suction valve movement during operation with the charger. The steadiness increases as the charger pressure is increased.

A corollary advantage to the direct elimination of knocking is that a considerable increase in pump speed can be made without damage. This per-

mits pumping a higher flow with a given liner size. Since severe knocking approximately doubles the stress cycles, elimination of knocking by the supercharger theoretically permits operation at double the speed at which knocking began. The theoretical effect of fatigue on part life would be the same in two pumps running at the same pressure; if one is operating at 50 spm and knocking, and the second is running at 100 rpm with knocking prevented by the use of an adequate charger.

A drilling contractor operating in New Mexico reported a saving of 70 hours rotating time as a result of supercharging. The contractor had wide experience in this area so he could compare this well to similar wells drilled in the same area and attribute this saving to the charger. With 7¾-inch by 18-inch pump operated at 52 spm it was possible to increase pressure by 100 psi to 200 psi more than normal without knocking, by increasing the mud pump speed and using supercharger.

This installation was made at a cost of $1,179, including labor, and saved $2,910 on this one well. This figure does not include savings from the extra life of slush pump parts because accurate costs were not previously kept. No valve or valve inserts had been replaced for 110 days after supercharging was begun. This was considered a remarkable record.

To increase hydraulic horsepower output below the knocking speed, a larger liner must be used. A larger liner, for example a 6½-inch, operating at the recommended pressure of a 5½-inch liner increases the bearing load in proportion to the piston area. Since bearing life is proportional to the load cubed, this reduces the estimated bearing life 63 percent for the 39 percent increase in hydraulic horsepower. The same increase in hydraulic horsepower could be obtained by running the 5½-inch liner at an increase in speed of 39 percent. Bearing life decreases in direct proportion to speed, so bearing life will be reduced by 28 percent.

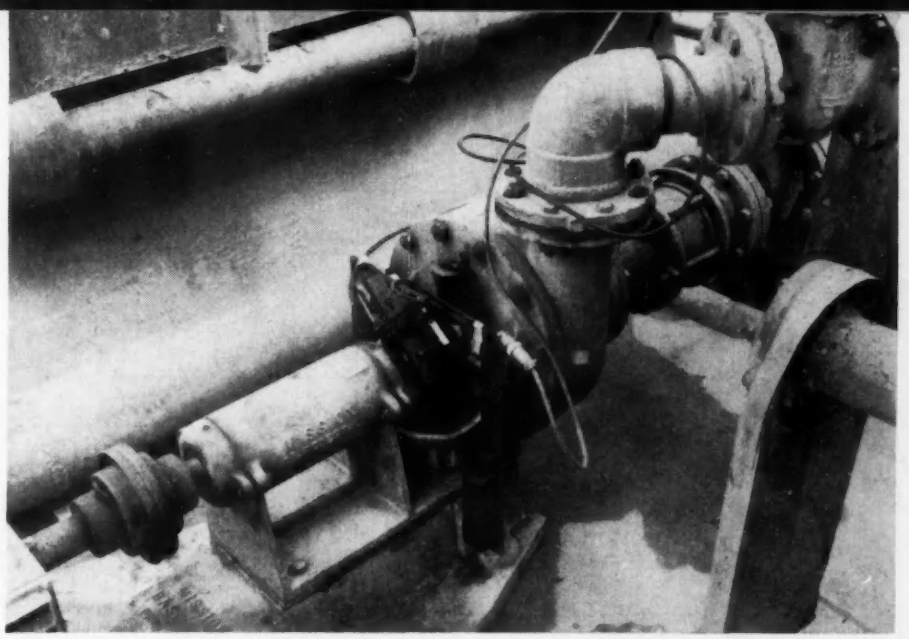


FIGURE 20—The vibrations or displacement of the charger shaft are being recorded electronically.

Thus, considerably higher hydraulic horsepower can be handled when supercharging with less reduction of pump life than would result from high pressure operation of the large liner.

Rocky Mountain installation. On this basis, an installation was made in the Rocky Mountain area with the specific intention of boosting slush pump output by operating at speeds above the manufacturer's recommendations. Even though mud tanks were used, severe knocking was experienced, before supercharging, at 72 spm, using 6¾-inch liners in a 7¼ by 14 pump.

After supercharging it was possible to operate the slush pump at 90 strokes per minute. Pump operation was considerably smoother at the higher speed with supercharging than at the slower speed without supercharging. The input horsepower available was boosted over 25 percent. Use of the input power available previously had been limited by the speed at which knocking developed. Since the charger raised the limiting speed by more than 25 percent, the possible horsepower also was increased 25 percent. With the increased hydraulics, faster drilling rates resulted.

After a full year of operation, the slush pump was disassembled and inspected. No damage or undue wear was found. In fact, the pump manufacturer reported that there was less wear than would be expected under normal operation.

Controlled volumetric efficiency tests on gas free mud gave identical results with and without the supercharger; some typical results are shown in Figure 22. When air appears in the mud either through leaks or separation, a noticeable improvement in volumetric efficiency occurs as the charger pressures are increased.

Figure 21a shows that when no charger is used, the suction pressure drops below atmospheric for a major portion of the stroke. Air can be sucked into the system at this time even if the mud is being pumped from a raised tank. Air which enters the system in this manner or which has been entrained in the mud tank or pit through jetting, whirlpools or gas cutting is partially compressed by the surge at the end of the stroke. A properly applied supercharger prevents a vacuum by maintaining a suc-

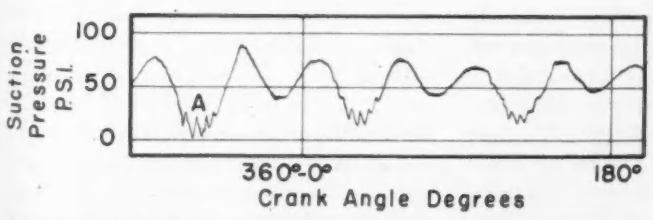


FIGURE 21a—When the charger pressure is too low, a vacuum occurs as at point A.

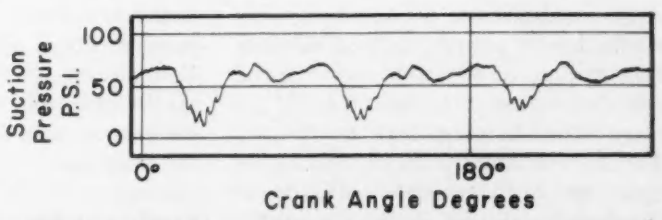


FIGURE 21b—Sufficient charger pressure eliminates suction pipe vacuum.

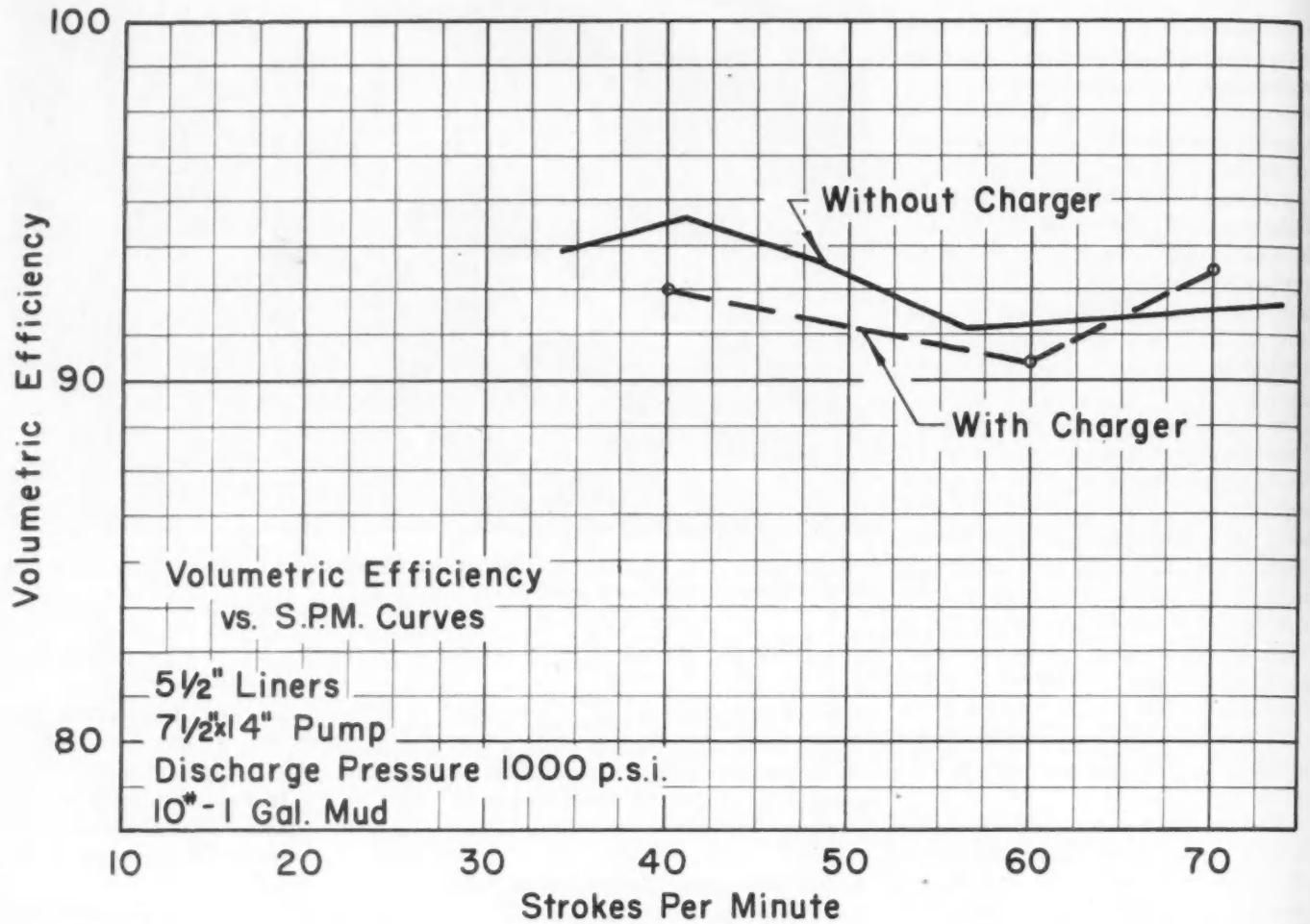


FIGURE 22—Controlled volumetric efficiency tests on gas free mud gave identical results with or without a supercharger.

tion pressure at all times. Thus, the air takes less space and the volumetric efficiency is increased.

With as much as 10 percent air entrained in the mud, a supercharger that raised the pressure as little as 50 psi would compress this volume of air to 2 percent of the mud volume in the slush pump cylinder. The volumetric efficiency would be increased by 8 percent. The supercharger would take little extra power to compress this air but the mud pump hydraulic horsepower output would be increased by 8 percent. A rough cost study shows that such a supercharger installation would cost far less than 8 percent of the cost of the mud pump installation.

In South Texas, an operator using a 7¼ by 18 pump reported satisfactory drilling at 800 rpm engine speed with an output pressure of 1,600 psi after supercharging. Before making use of the charger, a 20 percent higher speed had been required at a shallower depth to maintain circulation rates. Six-inch liners were used in both cases. Approximately the same circulation rate was obtained at the lower speed as a result of the better volumetric efficiency obtained by using a charger on this gas cut mud.

A slush pump will lose prime when working from a pit if the suction pressure drops below atmospheric and excessive air is drawn in the suction pipe through leaks in the system. A supercharging pump located at the pit and maintaining a positive suction pressure throughout the stroke eliminates this possibility.

Use of the supercharger increases the pump discharge pressure. In most cases, this is a relatively minor consideration. Tests indicate that the pressure at the start of a pressure stroke is increased by approximately the centrifugal pump pressure rating. Comparison of Figures 21a and 21b at the start of the stroke shows an increase in pressure in Figure 21a over the surge pressure in Figure 18 of 60 psi and in Figure 21b over the surge pressure in Figure 18 of 70 psi. These are approximate pressures developed by the centrifugal pump, as shown in Figure 19.

The discharge line pressures are nominally high enough to prevent any continuous supercharging effect through the cylinder into the discharge line. This ram effect may occur at very low discharge pressures which are unimportant in drilling operations. The discharge valves are always closed when a suction stroke begins, since they are hydraulically actuated, unless the parts are broken or jammed.

So the hydraulic horsepower of the rig is increased by the hydraulic horsepower output of the supercharger. Since installed hydraulic horsepower costs far less in the charger than in the mud pump, this is a good buy and is a reason for considering the use of the highest supercharger pressures available.

Location. Hydraulic horsepower available is increased if the supercharger is driven separately, and its greatest advantage can be realized by locating it at the pit end of the suc-

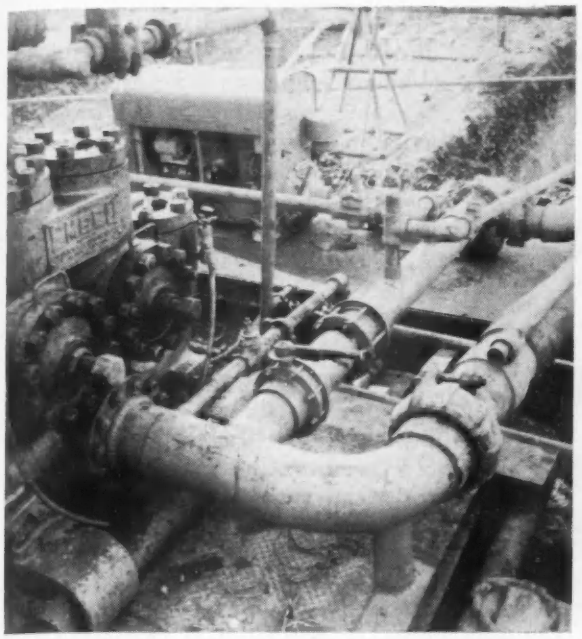


FIGURE 23—Use of an auxiliary engine to drive the centrifugal supercharging pump permits simplified piping and best pump location.

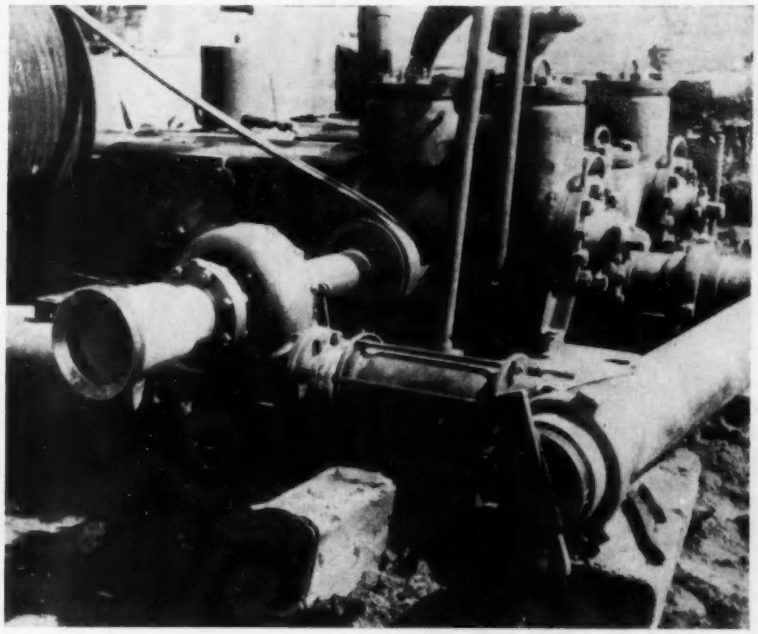


FIGURE 24—Slush pump powered installation. Note the expansion type coupling and provision for flexible hose connections to permit belt tension adjustment.

tion line. Figure 23 illustrates a supercharger pump with separate driver, located at the mud pit. This arrangement permits a short suction line to the centrifugal pump, and the output pressure from the supercharger is adequate to overcome all the demands of the line leading to the slush pump suction. The slush pump can be located most conveniently farther from the mud pit and with more suction pipe ells if necessary, without harm, as long as the supercharger keeps pressure on the slush pump suction and the dynamics of the centrifugal pump suction line are satisfied as indicated later in this article. The hydraulic horsepower of this skid-mounted unit increases the total rating of the rig.

Many advantages can be obtained by installing the supercharger on the mud pump skid and using a belt drive from a common driver. An installation of this type is shown in Figure 24. Although this does not increase the total hydraulic horsepower available, it does make possible the effective use of the horsepower on hand. A supercharger mounted near the mud pump will correct many of the problems resulting from gaseous mud and will increase the speed at which knocking develops. The increase will not be as great as it would be with the charger placed at the end of the suction line. The estimating method shown below makes it possible to decide which plan can be used for a given problem.

How to estimate supercharger requirements. A crude estimate of the accelerating ability of a centrifugal pump can be made from the standard performance curve if it is assumed that the pump response to changes in flow will be satisfactory. The pump manufacturer should be able to recommend the particular design necessary for good response to rapid changes in flow.

The selection of a supercharger is based on suction requirements presented in the second article of this series. The supercharger must meet two requirements:

A. For a charger near the suction tank or in the suction pit.

1. The charger must develop a pressure (P_t) at the start of the stroke that will equal the mud pump losses (P_p) plus the pressure required to speed up the mud in the entire suction line (P_s). In the absence of more applicable data, the typical values found in article two can be used for (P_p) (the pump losses).

$$P_t = P_p + P_s + P_m$$

The total pressure (Pt) required at 70 spm as shown in Figure 10b, Article 2, for the 7½ by 14 pump is 24 psi.

2. The charging pump must develop this pressure and operate without cavitation at the maximum instantaneous flow rate of the mud pump which is approximately Equation (E3) $Q = .01068KSND^2$. To select a supercharger for the duplex pump considered in Figure 10b, Part 2

Q = Capacity gpm
S = Stroke in.
N = spm
D_p = Piston dia.
K = 1.5 for double acting duplex.

At $S = 14$ in. $N = 70$ spm $D_p = 7\frac{1}{2}$ in.
$K = 1.5$
$Q = .01068\ (.15)(14)(70)(7\frac{1}{2})$
$= 882$ gpm

This is much greater than the average flow rate (720 gpm) of the 7½ by 14 mud pump even at 70 spm. The charger should be selected for a higher speed possibly 90 spm at which Q = 1135 gpm.

The capacity figure may have to be ignored in order to select a pump with reasonably large piping connections for small mud pumps. If the connections are small, the fluid going through the charger would require extra pressure to accelerate the flow variations through these restrictions. The pressure at this point should be as high as possible consistent with the requirements of one above to reduce surging. This means that the impeller curve should have a flat characteristic dropping as little as possible with increase in flow.

3. The pressure required at this higher speed can be estimated roughly by reference to Equation E1 and E2, Part 2. In Equation (E2), the pressure required (P_s) is directly proportional to the piston acceleration (A_P).

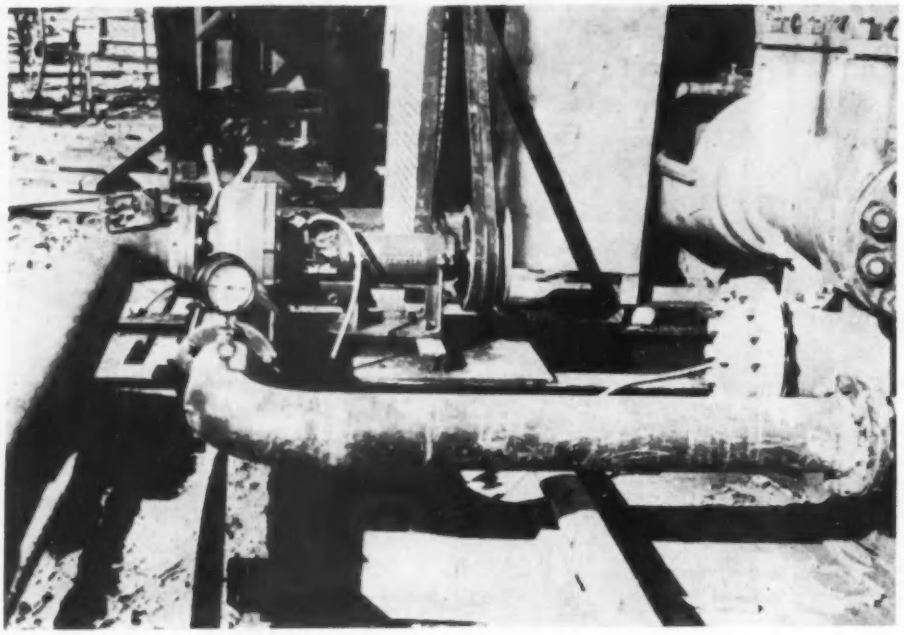


FIGURE 25—Belt drive directly from the slush pump sheave reduces first cost.

In Equation (E1) the piston acceleration is proportional to the pump speed (N) in strokes per minute, squared. Therefore, the suction pipe pressure required (P_s) is proportional to the pump speed (N) squared. In addition, since about 80 percent of the pump losses (P_P) have been found to be proportional to the piston acceleration we can add the suction pipe loss (P_s) and the pump loss (P_P) as follows to estimate the requirements at high speeds. This will give us an estimate on the safe side if we go to a higher speed than one for which test data is available.

Equation (E4):

$$P_{t2} = \left(P_{s1} + P_{p1} \right) \times \left(\frac{N_2}{N_1} \right)^2 + P_m$$

Where

P_{t2} = Total press. req. at new speed when P_t^2 is total pressure at the new speed or at
P_{s_1} = Pressure req. to accelerate mud in suction pipe at test speed.
P_{p_1} = Pump losses at test speed
N_2 = New Operating Speed spm
N_1 = Pump speed, spm
P_m = Misc. losses including vapor pressure

From Figure 10, Art. 2

at N1 = 70 spm
$P_{s_1} = 13.5$
$P_{p_1} = 9$ psi
$P_m = 2$ psi

$$P_{t_2} = (13.5 + 9)\left(\frac{90}{70}\right)^2 + 2 = 39.2 \text{ psi}$$

The simplification in Equation (E4) reduces the accuracy; this is unimportant because:

(1) The error is only a few pounds.

(2) A charger can easily be selected to develop the extra pressure.

(3) The pressure is not wasted but is an increase in hydraulic power for the rig.

B. For a supercharger between the suction reservoir and the mud pump.

The estimate for the section between the supercharger and the mud pump should be made as in A above. The estimate for the pipe from the reservoir to the centrifugal pump should be made as indicated in Article 2. This is necessary because all of the unsteady flow characteristics described in Article 2 occur in this section of the suction line, as they would if the charger were not there. If the atmospheric pressure is not high enough to keep the eye of the supercharger impeller full during pulsating flow, voids occur, and audible knocking takes place in the supercharger. This causes cavitation and vibration in the supercharger, increasing wear and causing packing difficulties.

Other advantages. There are other advantages to supercharging that have been reported from the field and which should be considered. The rotary base and swivel frequently operate with less kick, probably because of air or gas volume reduction. A supercharging installation requires that additional slush pump suction piping be provided, and suitable valves arranged so that the slush pump can take suction either from the centrifugal pump or directly from the mud tank or pit. An auxiliary engine to drive the centrifugal pump is desirable, but most installations have been made utilizing a belt drive from the slush pump sheave. Depending on the particular arrangement chosen, the cost of a supercharging installation ranges from $1,000 to $4,000 (where an engine is included) of which the centrifugal pump cost is $500 to $600.

The maintenance cost of a supercharging installation generally is so slight as to be inconsequential when compared to the maintenance costs for a conventional slush pump. Parts last from 6 to 12 months where mud having a high sand content is used, and considerably longer under normal conditions. It is necessary that the stuffing box be properly cared for, however, or excessive shaft wear and packing expense results. Some form of packing lubrication should be provided such as water, oil or grease. The lubricant must be introduced at a pressure that will prevent abrasive laden mud from entering the stuffing box, and the packing must be operated only hand tight.

When rigging up, accepted good practices for the supercharging pump suction piping should be followed: short lengths, few bends, adequate size, minimum fittings, tight connections. The centrifugal supercharging pump will fill as the fluid is pulled through it by the slush pump, so normal slush pump priming methods can be used.

Exact horsepower requirements depend on mud weight and slush pump size and operating conditions, but three C-Section or two D-Section V-belts usually are adequate when power is taken from the slush pump. Twenty to 30 horsepower is scavenged from the slush pump driver. With a separate supercharger driver, at least 30 to 60 horsepower should be available, and more if an extra hydraulic boost is intended.

A supercharger now is a proven method of squeezing more from the drilling dollar:

- By providing less expensive hydraulic horsepower.
- By more fully utilizing existing horsepower to give faster penetrative and
- By more efficient smoother operation of slush pump, to reduce wear of reciprocating pump components.

TO BE CONTINUED

Contractor can save time and money by . . .

Proper selection of engine compounds

Adequate compound maintenance must be practiced for efficient operations

By M. Duane Lackey, Development Engineer
Unit Rig and Equipment Company, Tulsa

THESE ARE the factors which should be considered in the selection of a drilling engine compound:

- The drive component elements, particularly the chain and clutches.
- The size of compound.
- The flexibility of the compound engine.
- The type of compound; inline, sectional or a swinging type.

Figure 1 shows a three-engine two-pump drive compound and illustrates the type of information that might be given in a manufacturer's bulletin or a proposal drawing. This is sufficient

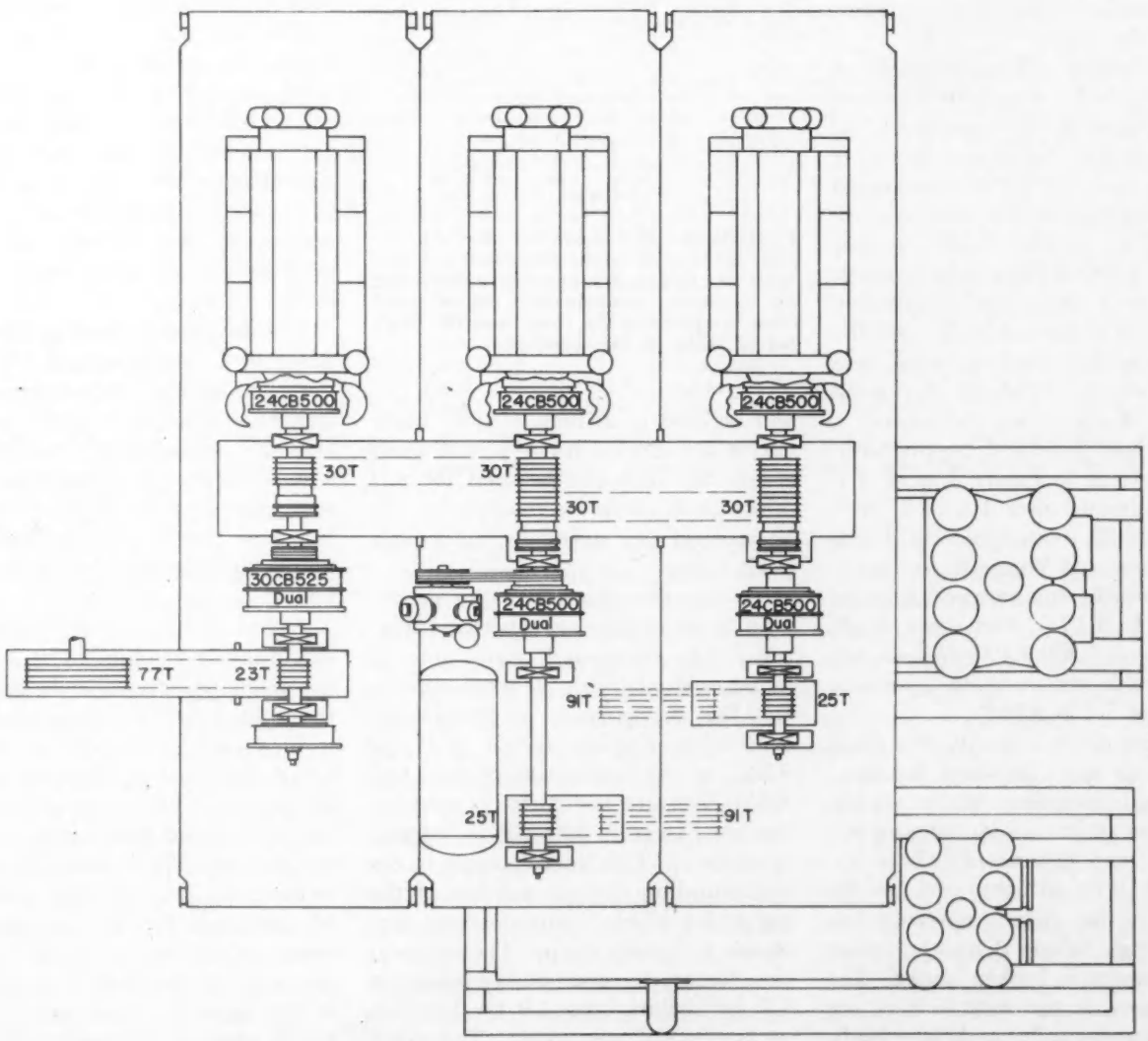


FIGURE 1—This is a typical three-engine two-pump drive compound.

to check the chains for maximum speed and horsepower capacity. The clutches are defined and can be checked for horsepower capacity.

However, sufficient information for checking the shafts and bearings is not included. Since compound design is based on loads transmitted by the chains, the horsepower capacity of the chains should represent the horsepower capacity of the complete compound.

New information is available which allows a more thorough analysis of oil field chain drives.[1] This information is based on experimental investigation of press fit center plate chain, and the horsepower capacity shown is applicable to that type of chain only. However, since all American Standards Association chain is made to the same basic dimensions, the curves should be useful for comparing the horsepower capacity of different compounds, regardless of the type of chain used.

Further, the curves exhibited in this article represent an interpretation of the information rather than a presentation of that data.

The maximum allowable speed of compound chains should be checked, because engine speeds have been increasing in the last several years. A few years ago, 900 RPM represented the maximum speed for most large oil field drilling engines. Today, engine speeds of 1,300 RPM are in common use. Figure 2 shows the relationship between the chain pitch, the number of teeth on the small sprocket, and the maximum RPM of the small sprocket. Exceeding this speed is likely to cause galling of the pin bushings. Referring to Figure 1, note that this compound uses 1½-inch pitch chain over 30 tooth sprockets. Using these figures and Figure 2, the maximum allowable engine speed is found to be 1,240 RPM. This drive might be used with 1,300 RPM engines, but safety would increase if the governors were set at 1,250 RPM.

The horsepower capacity of a chain is somewhat more involved, however, the normal procedure can be simplified by use of the graph (Figure 3). Note that two criteria of failure are presented. The straight lines on the left side of the graph represent link plate fatigue. Failure due to link plate fatigue results in broken chains. The curved lines on the right side of the graph represent roller and roller bushing fatigue failure due to impact between the chain and the sprocket. Failure due to the roller bushing fatigue criteria is indicated by broken rollers and roller bushings. While this may result in a rough drive that will require the chain to be replaced, it does not make the drive inoperative.

Each chain drive must be considered individually because of varying requirements in dealing with fatigue criteria. Consideration must be given to the required chain life and the chain length, as well as the number of teeth in the sprocket and the sprocket speed. These are shown as application factors. Thus, a compound chain will transmit 1.9 times the horsepower shown on the graph for the relatively short period of time it will be used in drilling service. These curves are drawn for 1½-inch pitch chain, but they can be used for any other pitch chain by multiplying the horsepower per strand by the proper pitch factor.

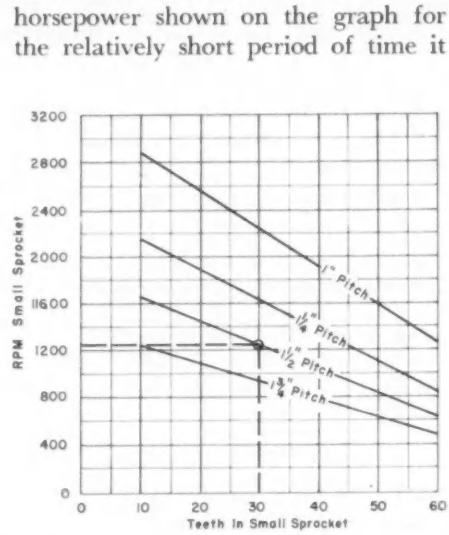


FIGURE 2—The maximum allowable engine speed is of great importance. Using the above figure, it is possible to determine the maximum recommended engine speed from the pitch of the chain and the number of teeth in the sprocket.

To illustrate the use of this graph, refer to the compound schematic, Figure 1. The compound chains are 1½ inches sextuple with 30 tooth sprockets. For the purpose of illustration, assume an engine speed of 1,000 RPM. At the intersection of the 1,000 RPM line and the 30-tooth sprocket line on Figure 3, 180 HP per strand is indicated. This intersection is in the roller bushing fatigue portion of the curve, for which failure does not represent a broken chain. The application factors for compound chains are 1.0 for drilling and 1.9 for hoisting, as previously mentioned. The pitch factor for 1½-inch chain is 1.0.

Therefore, the sextuple chain will transmit 180 x 6 x 1 = 1,080 HP for drilling and 180 x 6 x 1.9 = 2,052 HP for hoisting. Similarly, the 25-tooth pump drive will transmit 132 x 6 x 1.15 = 910 HP, and the 23-tooth drawworks drive is rated at 120 x 6 x 2.1 = 1,510 HP.

Figure 4 shows the relationship between RPM and horsepower capacity for various constricting type periphery clutches. These clutches are particularly adaptable to engine clutches and pump clutches. They are widely used. The 1.8 service factor is applicable for this type of service. Note that these ratings are based on 100 psi air pressure. The clutch capacity can be considered as being directly proportional to the applied air pressure. This is not exactly true, but the error between 75 psi and 125 psi will be small.

Thus, the engine clutches in our example compound (24CB500) will transmit 615 HP at 1,000 RPM. The dual 24-inch pump clutches will transmit 1,230 HP, and the dual drawworks drive clutch or master clutch (30CB525) will transmit 2 x 840 = 1,680 HP. If the system air pressure is 90 psi, the clutch capacities would be 90/100 times the capacities listed above or 554, 1,108, and 1,512 HP, respectively. Generally speaking, engine and pump clutches are optional items and may be selected by the purchaser to suit his own requirements.

The stresses or bearing life expectation in a compound shaft is beyond the scope of this article because of the lack of desired information presently available in catalogs and bulletins. The loads can be determined, however, the location of the loads and bearings, the size of the shaft at all points, and the shaft material are unknown.

A few points about bearings and shafts may be helpful. For a particular shaft, the stresses vary directly as the applied torque. Thus, horsepower is increased 25 percent at the same speed the shaft stresses are increased 25 percent. The normal method of rating installed bearings is to specify the expected life in hours. Bearing life is inversely proportional to the cube of the load. For a particular shaft, bearing load would be directly proportional to the applied torque. Thus, if the applied torque were increased by 25 percent, the bearing life would be reduced to 51 percent of the origi-

nal life. Bearing life also is inversely proportional to the rotational speed.

Flexibility of power assignment of an engine compound is represented by the number of compounding clutches included in the drive. The compound illustrated in Figure 1 has three compounding clutches. Not only can each of the three loads be driven independently, but also any two engines can be compounded to one load, such as one of the pumps, while the third engine can drive another load independently. Similarly, any load can be driven by two engines while either of the other loads is being driven independently by the third engine. All three engines can be compounded and assigned to any one load.

Certain three-engine compounds have only one compounding clutch located so that the No. 1 engine can be used to drive the rotary independently while the No. 2 and No. 3 engines are permanently compounded and can be assigned to either or both of the two pumps. If two compounding clutches are used, say on the No. 1 and No. 3 engines of the illustrated compound, flexibility is improved as can be seen. This usually represents all of the flexibility of power assignment that is required, and the third compounding clutch usually is sold as an optional extra.

Most compounds can be classified into one of three familiar types. They may be an inline compound, a sectional compound or a swinging compound. Each type has its advantages and disadvantages.

Small drilling rigs, including trailer-mounted rigs, invariably use an inline compound.

The inline compound is a one-piece unit and has all of the shafts mounted in a common case. It is particularly adaptable to unitized drawworks where the drawworks, compound and engines can be moved in one load. It is the type of compound normally used on independent pump drives where more than one engine is used. The inline is an efficient type of compound in large sizes up to the point where engines must be removed from the compound during moves either because of weight or width limitations.

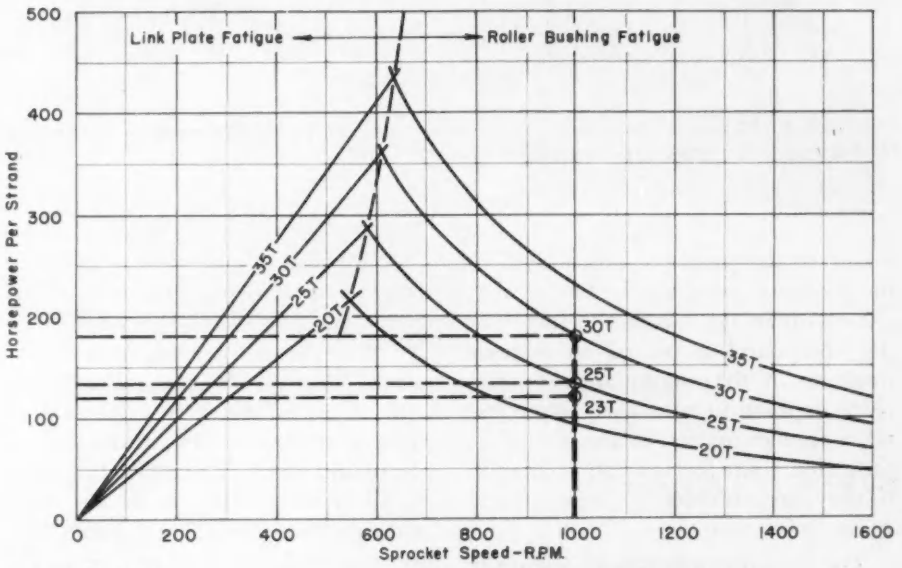
An example of a medium horsepower inline compound is shown in Figure 5. Engines on an inline compound usually are mounted on individual skids and connected to the compound shafts with flex-couplings or periphery clutches. The prime advantage of an inline compound is that the oil tight integrity of the chain case is maintained at all times. The case never is opened except for maintenance. Thus, foreign agents such as dust, sand and water are kept away from the chains and bearings.

The disadvantages of an inline compound can be attributed to size. Large engines must be removed during rig moves and realigned at rigup. This can be a more involved procedure than replacing the chains and bolting together the sections of a sectional compound. A further disadvantage of the inline compound arises when more than one pump drive is required. The standard arrangement of an inline compound has provisions for one pump drive behind the rear engine. When a second pump drive is required, it usually is added as an appendage to the side of the compound. This side pump drive must be removed for transportation and replaced at the next rigup.

The compound schematic diagram shown in Figure 1 illustrates a sectional compound. The particular compound shown was made for a drilling barge installation with the pumps located under the compound and with heat exchanger cooled enginees. With these exceptions it represents a typical three-engine sectional compound.

The sectional compound is made in sections as the name implies. Each engine, together with the engine compound shaft and a section of the compound case, is mounted on a separate skid. Pump drive shafts are mounted on the same skid sections, usually mounted as extensions of the engine shafts. There is sufficient room to mount an air compressor, air receiver and any other desired accessories directly on the section skid.

If desired, the walkways, engine sheds, etc., can be built on the skids and kept as a unit during moves. Since the engine, compound shaft and pump drive shaft, where used, are mounted to the section skid, the clutch and coupling alignment generally is maintained during moves. This



LINK PLATE FATIGUE

Pitch	Factors
1″ Pitch	0.36
1¼″ Pitch	0.72
1½″ Pitch	1.00
1¾″ Pitch	1.52

ROLLER BUSHING FATIGUE CORRECTION FACTORS

Application	Factors Compound Chain
Drilling	1.00
Hoisting	1.90
Drawworks Drive	2.10
Pump Drive	1.15

Pitch	Factors
1″ Pitch	0.615
1¼″ Pitch	0.77
1½″ Pitch	1.00
1¾″ Pitch	1.09

FIGURE 3—The horsepower capacity of a chain may be calculated from this graph. Two types of failures are presented on the graph—link plate fatigue and roller bushing fatigue.

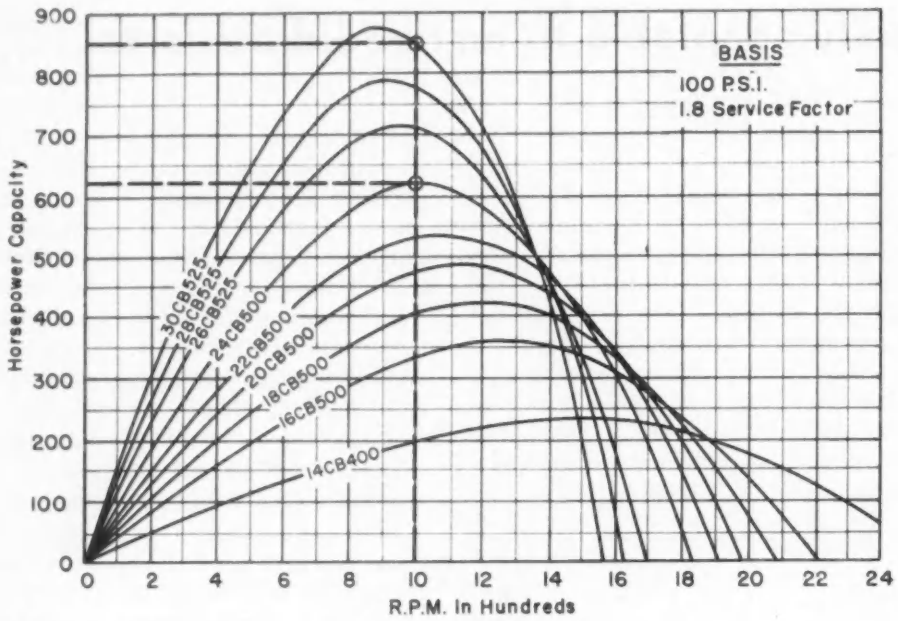


FIGURE 4—Illustrated here is the relationship between rpm and horsepower capacity for various constricting type periphery clutches.

is one of the principal advantages of the sectional compound. The principal disadvantage lies in the fact that the compound is moved in sections resulting in the chains and bearings being exposed to sand, dirt, water and other foreign matter. Bearings may be protected from foreign contamination if they are completely enclosed and grease lubricated.

The swinging compound, Figure 6, is a combination of the sectional and inline compounds. It is similar to the sectional compound in that each engine is mounted on an individual skid. The compound case chain drives are enclosed in individual chain cases. These compound cases are mounted on split retainers so they may be swung to a vertical position for moving. The drawworks drive on this compound is made in the same manner. It is shown in a vertical position and illustrates the swinging principle. This permits the skid to be split without opening the chain cases, breaking the chains, and exposing all of the precision parts to foreign material.

The pump drives and auxiliary equipment are permanently mounted on the same skids as the engines. The swinging compound, like the sectional, is large and is accessible for service of the equipment. For over the road moves, it may be necessary to remove the case instead of leaving it vertical, so clearance may be obtained for bridges and overhead obstructions.

Compound maintenance begins at rigup. For proper operation and proper transfer of loads, it is imperative that the compound skids be securely fastened to the substructure with shims where it is important to prevent unnecessary strains in the compound skids. The skids furnished on all types of compounds are made of large steel structural shapes and are quite stiff, but they will bend. For this reason, clutch and coupling alignment is not necessarily maintained even on sectional or swinging compounds unless the compound is properly shimmed and bolted to the substructure.

Flexible couplings and periphery clutches are used to connect the engines and the pump drives to the compound shafts because they will take a certain amount of misalignment. They are suited for this task. When misalignment exceeds a certain amount, the life of these couplings is shortened. Excessive misalignment of a periphery type clutch results in a radial load which is transferred to adjacent bearings. While this load may have little effect on the life of the compound shaft bearings, it is to be regarded with suspicion because of its possible effect on the life of the engine crankshaft main bearings. For this reason, coupling and clutch alignment should be checked at each rigup with a dial indicator and in accordance with the manufacturer's recommendation.

Compound lubrication usually is covered quite adequately in the manufacturer's recommendations, but there are a few points that should be emphasized.

Dirt and sand make poor additives for oil, and necessary precautions should be taken to prevent the ap-

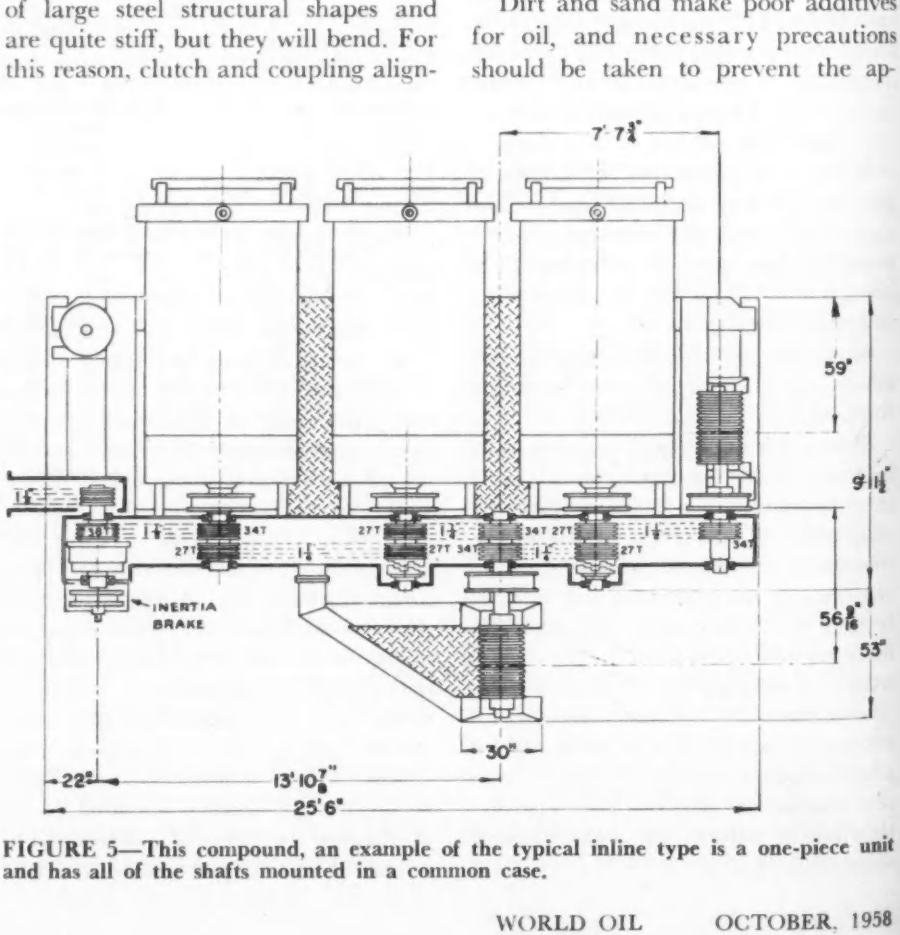


FIGURE 5—This compound, an example of the typical inline type is a one-piece unit and has all of the shafts mounted in a common case.

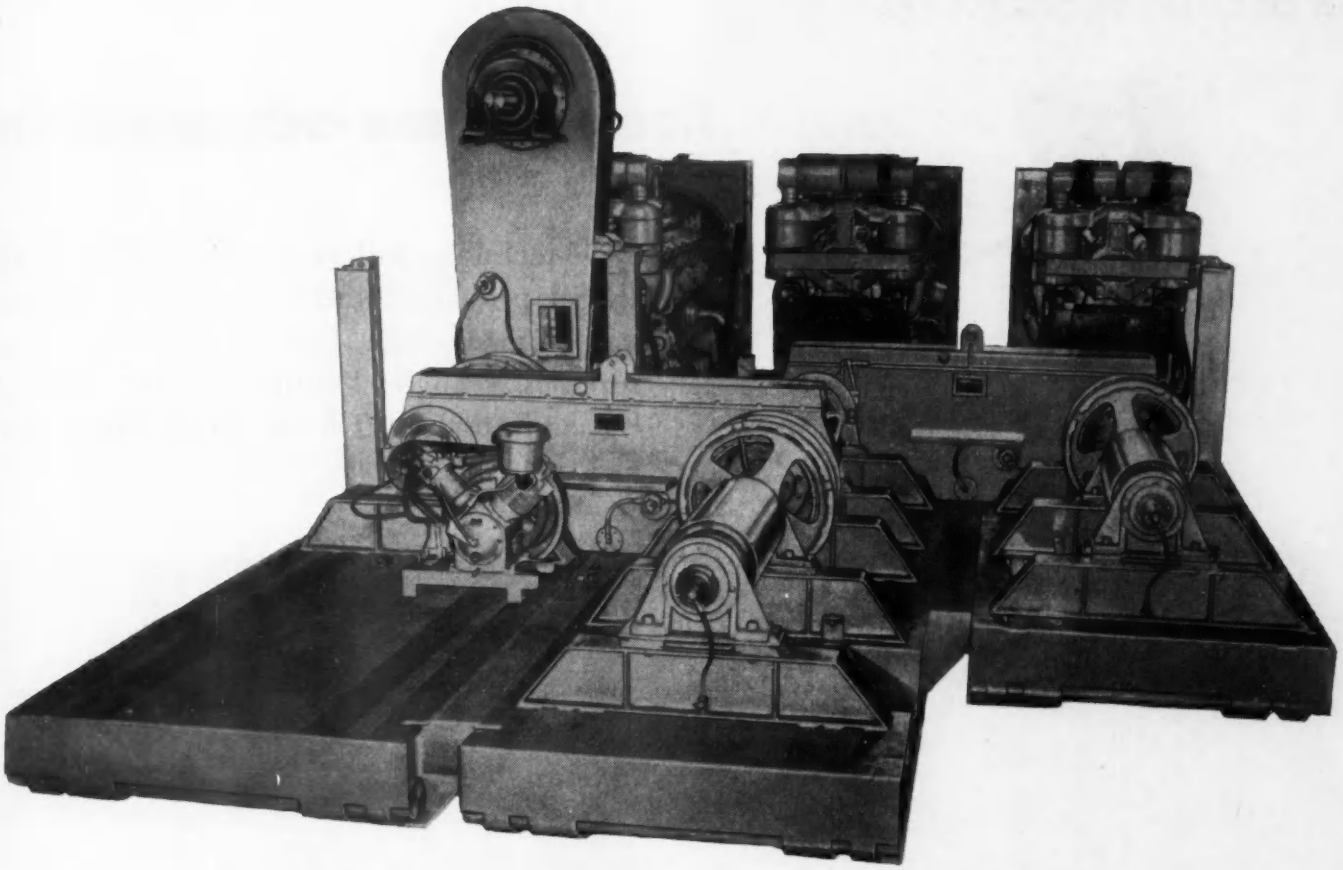


FIGURE 6—This swinging compound is a combination of the sectional and inline compounds.

pearance of any such foreign matter. Chain links, tools, nuts and bolts do no harm in the bottom of a chain case, however; soft rope, rags and gloves could plug the oil lines, strainers and/or oil pump resulting in a plugging action of the lubricating channels.

Dirt and sand will accumulate in a chain case after a period of time unless the case is drained and cleaned periodically.

Water from various sources tends to accumulate in a chain case. A floating type of strainer will skim the oil from the top, but it usually has a limited amount of travel. If the water is not drained and does not leak out of the case, eventually it will be circulated to the bearings and chain.

Oil filters on compounds require some service. They do a satisfactory job when operating, but unless they are serviced periodically they will cease to function properly.

Another cause of lubrication failure is broken or mislocated oil lines. When a compound chain breaks, an oil line can easily be broken. Therefore, when a chain is replaced, careful inspection should be made to make sure that all bearings and chains are being lubricated.

All material items wear out eventually and roller chains are no exception. A roller chain is worn out when it is stretched 3 percent of its original length. Thus, 20 pitches of a new 1½-inch pitch chain will measure 30 inches between the centerline of the extreme pins. When the chain has elongated so that it measures 30.9 inches or more, it is worn out and should be replaced. The chain will have little life left because it has practically worn through the hardened case of the various component parts. Further, the pitch of the chain will be longer resulting in easily replacement of the chain and sprockets.

The importance of the engine compound to the successful operation of a drilling rig is obvious. The purchase of a new compound may represent a substantial investment. Consequently, it behoves an operator to select a compound with the proper horsepower capacity, the desired flexibility, and the necessary configuration to suit his requirements. By the same token, proper maintenance of a compound is good business.

REFERENCE

1 "Proven Concepts in Oil Field Roller Chain Drive Selection," by Messrs. R. A. Schakel and C. O. Sundberg, Diamond Chain Co., Indianapolis, Ind.

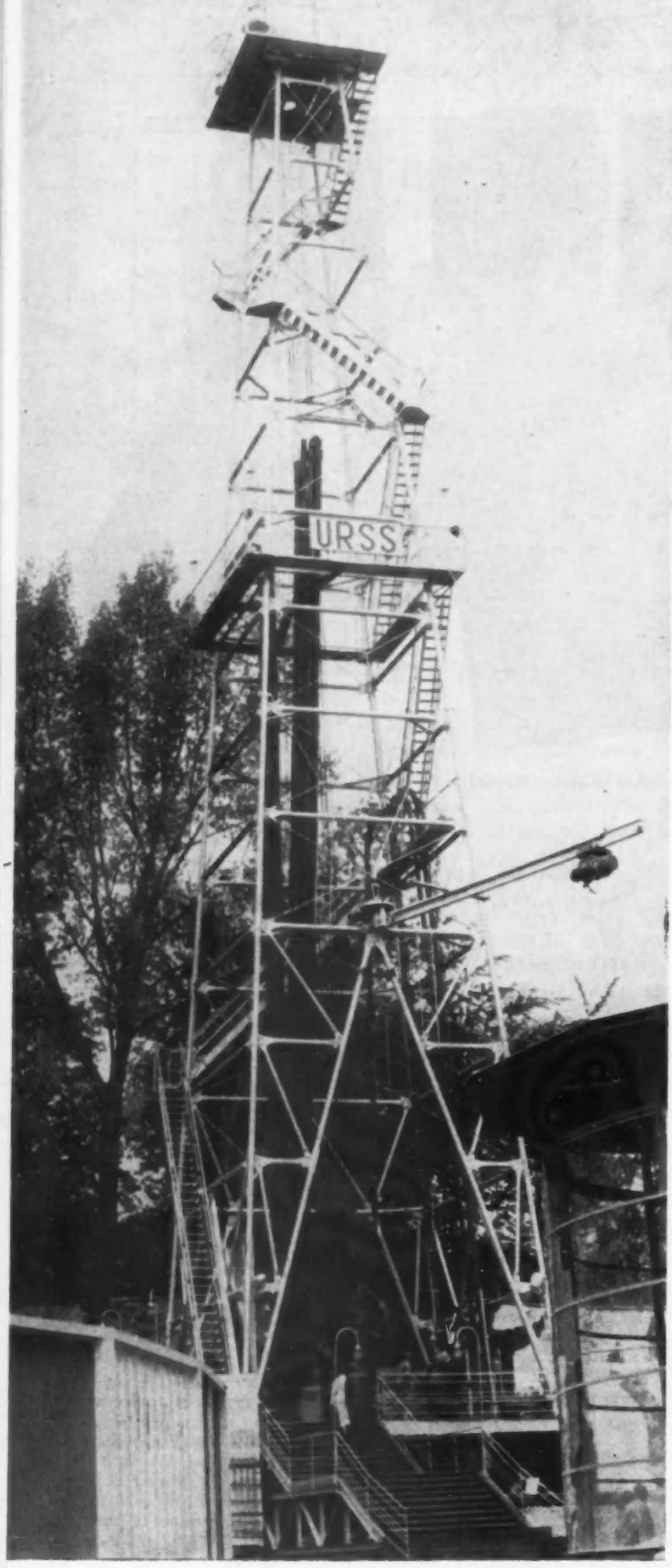
About the Author

Duane Lackey received a B.S. degree in mechanical engineering from Oklahoma A & M College in 1941. He was employed in the Technical Training division of the Westinghouse Electric Corp. He joined the Army Air Forces in 1943 and served until 1946. He was a member of the Engineering department of the Bethlehem Supply Co. from 1946 to 1952 at which time he joined the Unit Rig and Equipment Co. He is a registered professional engineer in the state of Oklahoma and a member of American Society of Mechanical Engineers.

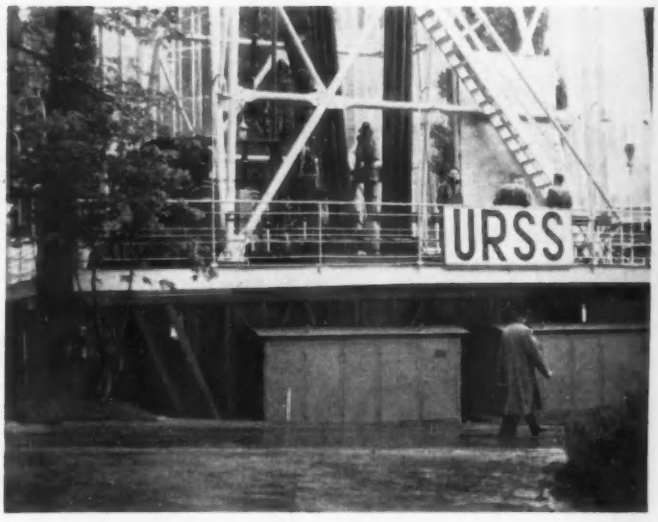
A DRILLING PROGRESS FEATURE

Russian advances in d

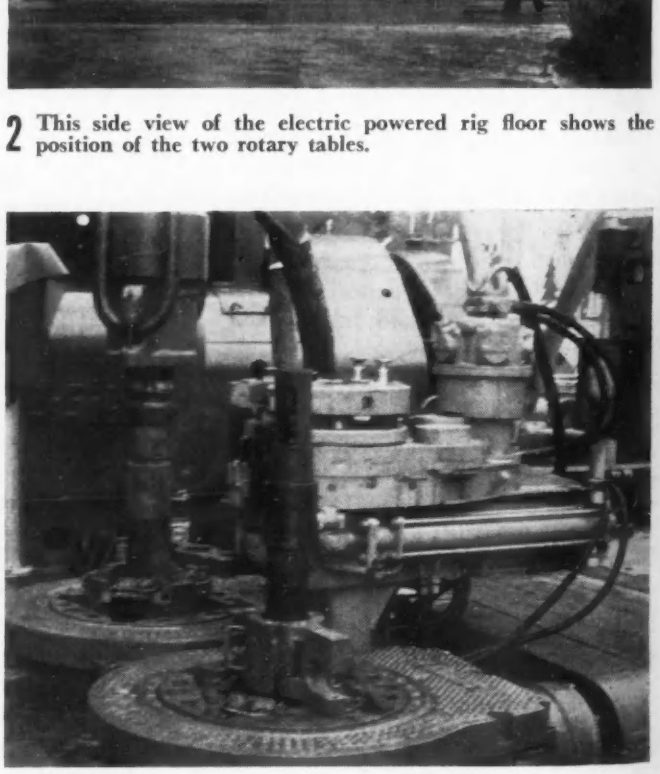
New technological concepts developed by USSR presented and explained in display staged at World's Fair in Brussels. Featured is a Soviet seamless tubing drilling rig, equipped to drill two holes from same location



1 The Russian derrick on exhibit at Brussels is of standard design and is constructed with seamless tubing. Height of the derrick is approximately 140 feet, and the floor is about 10 feet above ground level. The truss type substructure allows for a 30-foot square floor on which are mounted the 16,500-foot capacity drawworks, braking system and power transmission equipment. The rig is electric powered rated at 660 kilowatts.



2 This side view of the electric powered rig floor shows the position of the two rotary tables.

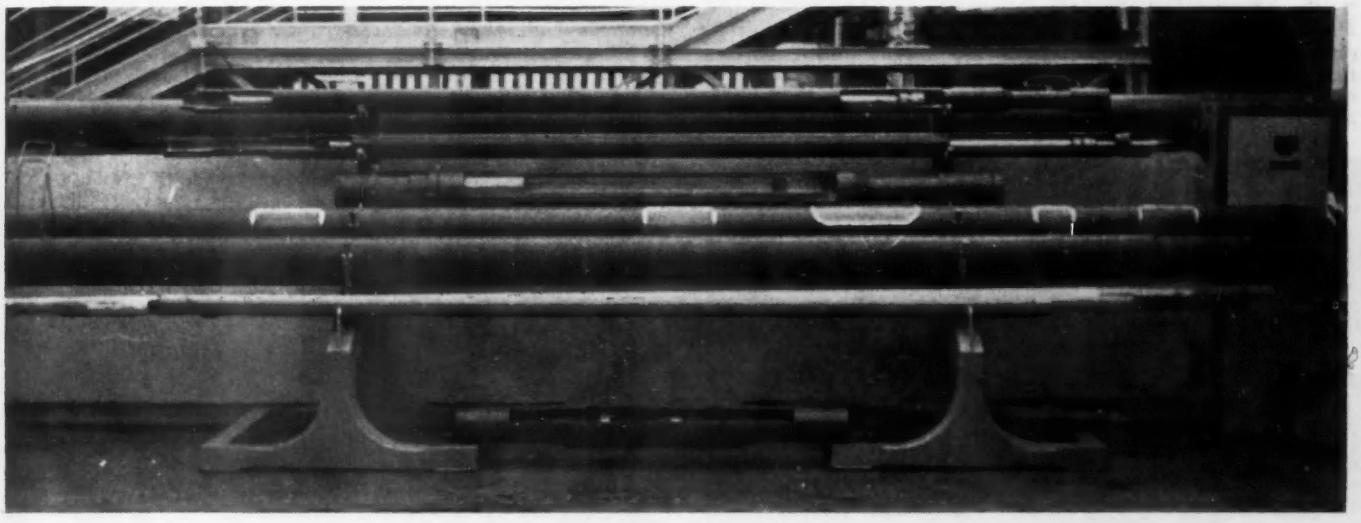


4, 5, 6 This close-up view of the two rotary tables, which can be used to drill two holes at one time, also shows the automatic pipe tongs. Russians say that with this two-rotary system two holes can be drilled from the same location. The drill pipe in one hole is hoisted from that hole and returned to the second hole without standing in the derrick. One hole must stay opened while a bit is being dulled in the other. Also, with

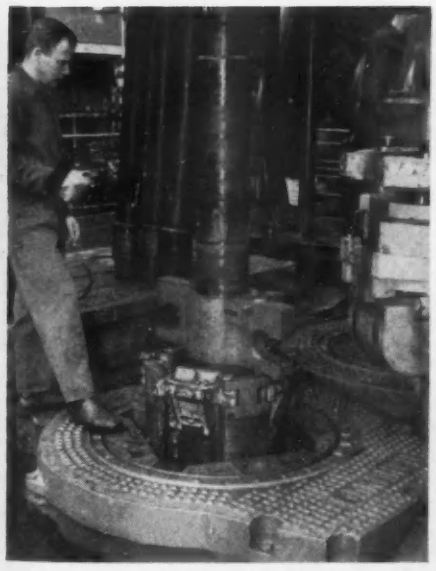
drilling equipment, techniques exhibited

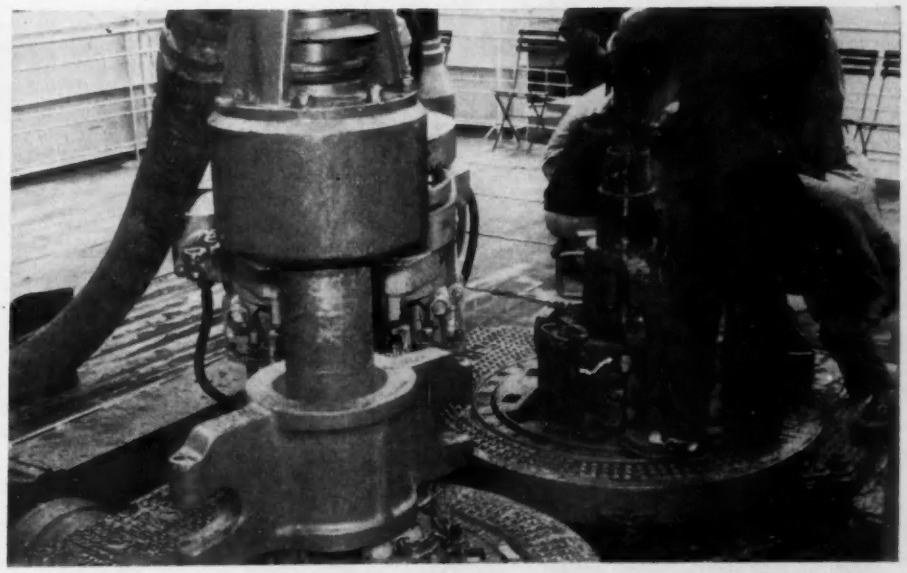
By John Workman
Reed Roller Bit Company, Netherlands

RUSSIA'S OIL EXHIBIT at the 1958 World's Fair in Brussels consists primarily of a drilling rig, fully equipped for drilling two holes from the same rig location. Although the basic design of the drilling rig, including the derrick, drawworks, braking equipment, power transmission, and drive system, differs little from the conventional type rotary drilling rig, the following photographs illustrate Russian drilling equipment that is different from the conventional equipment currently in use throughout the world.

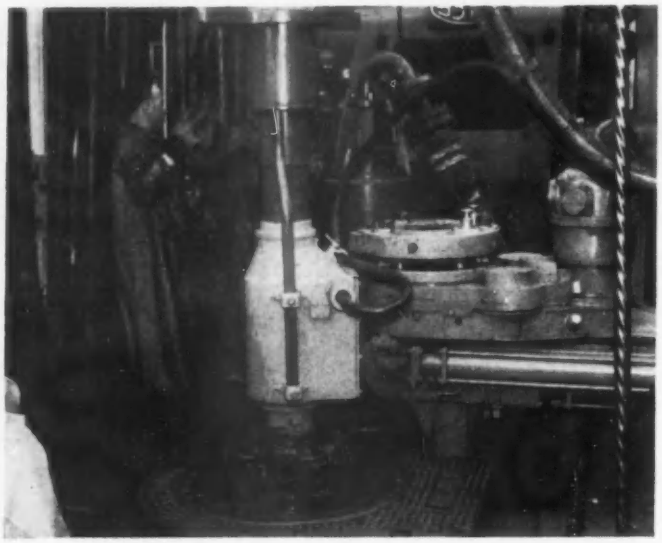


3 Various types and sizes of mud and electric turbodrill and turbo core drills are displayed in the exhibit. Russians claim that in 1957 about 90 percent of all oil and gas drilling was performed by the turbodrill method in the U.S.S.R.

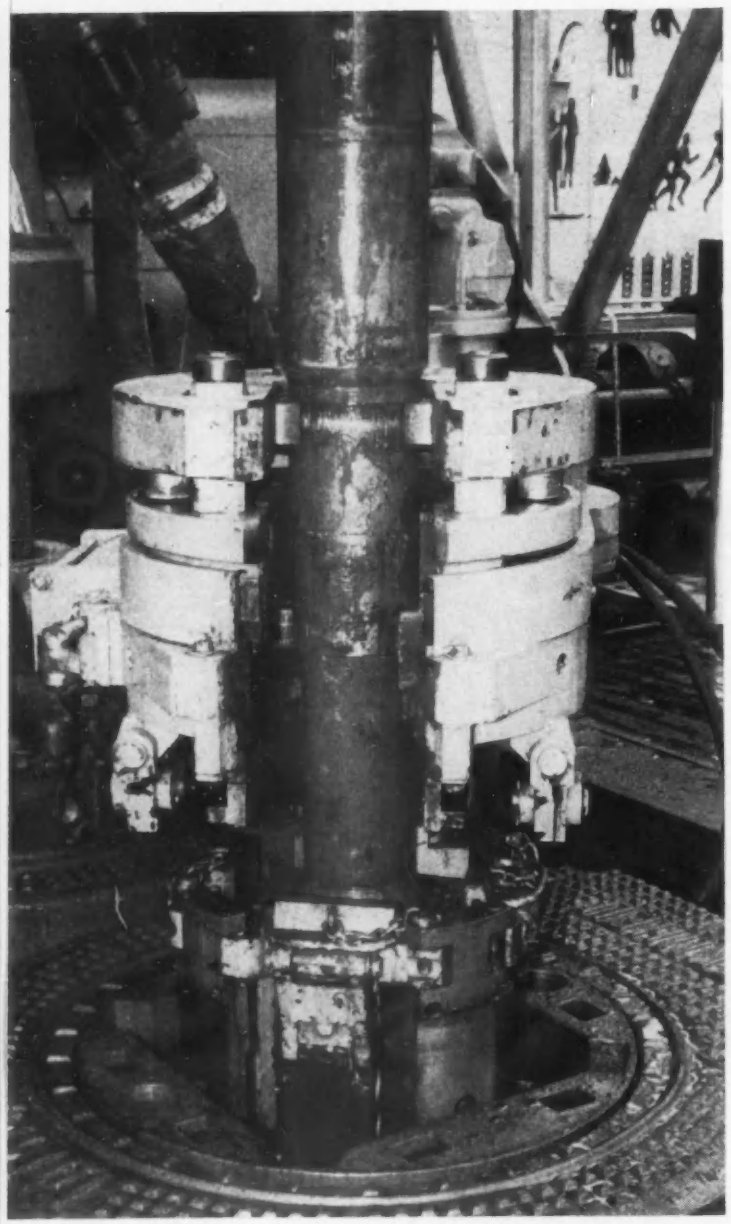


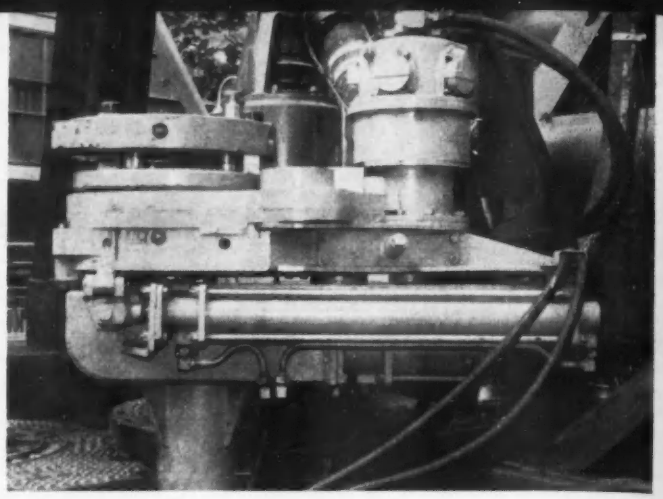


an additional feed-off mechanism, it is possible to drill in one hole without the hoisting system and, at the same time, to make a round trip in the other hole, or keep bits running on the bottom of both holes simultaneously. The setting unit consists of a small swivel (see 6) and a bushing spider (5). The upper part of the bushing spider forms a cone bowl for setting four special slips to hold the kelly. When the slips are set into the bushing spider cone bowl, the kelly then is held at any position of the swivel above the rotary table. The swivel has no bail and is supported by a one-piece steel cast elevator which has ears so the bail links can be attached when hoisting (6). The crown block on this rig is mounted on a track and is driven by an electric motor so it can be placed directly over the rotary table when needed.

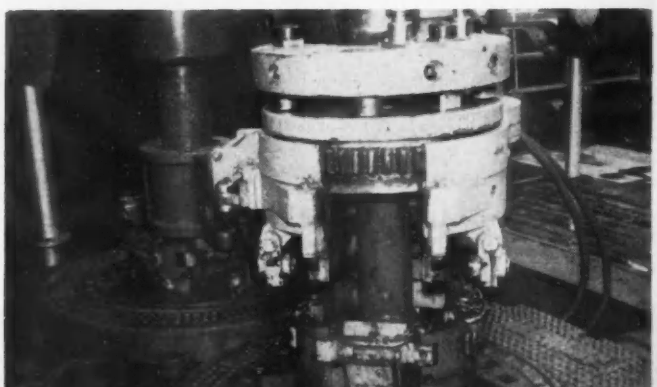


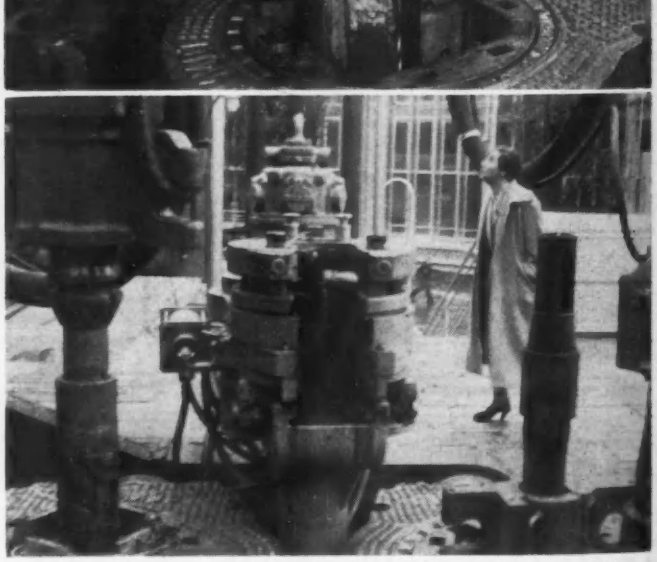
7 The power swivel, shown here, was in use while the electric turbodrill in the hole was being operated. The electric turbodrill is used in the same manner as the mud turbodrill for vertical or directional drilling of well bores. The electric turbodrill is powered by an electric motor which works close to the bit, and the power cable runs through the inside of the drill pipe.



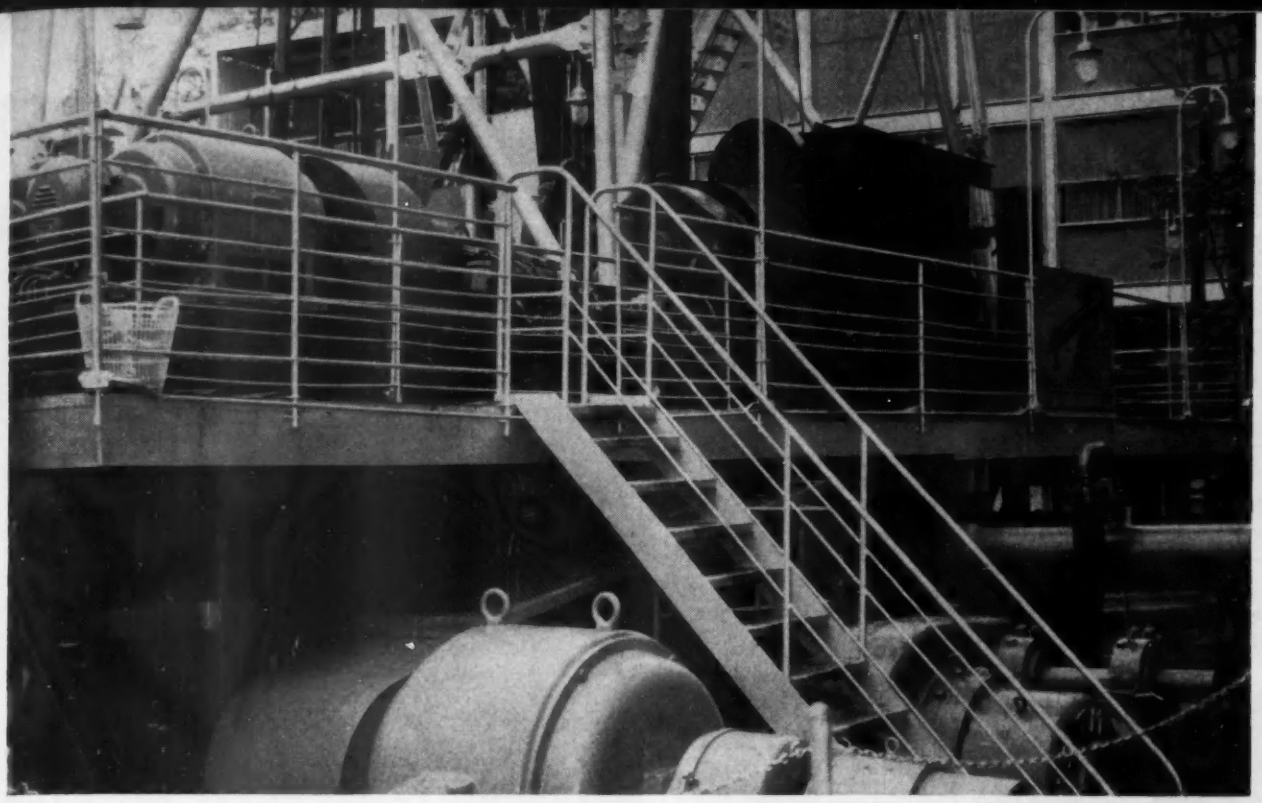


8 This is a side view of the automatic pipe tongs, or tongue, which is mounted on a stationary column between the two rotary tables and which can be pivoted to operate at both stations. These tongs are used for making up and breaking out tool joints or casing connections. The tongs are operated by a crew member from a control panel. The automatic pipe tongs consist of three main units—the tongue block, a slide with pneumatic cylinders and a control panel. The tongue block is the main part, performing the making up and breaking out of the joints. It consists of a body which is mounted on a pipe clamping mechanism, a step down reduction gear and a motor with a flywheel. The clamping mechanism includes two jaws which clamp simultaneously the pin and the box of the tool joints. The tongue motor drives the upper clamping device which has a cut-out ring gear which meshes with two idler pinions of the step-down reduction gear. When the upper clamping device is engaged, the tool joint is clamped and torque is applied by the gyration of the rotating parts. The maximum torque which can be applied by these tongs to the tool joints for making up is 18,200 foot/pounds. For breaking out, the maximum torque available is 43,500 foot/pounds.

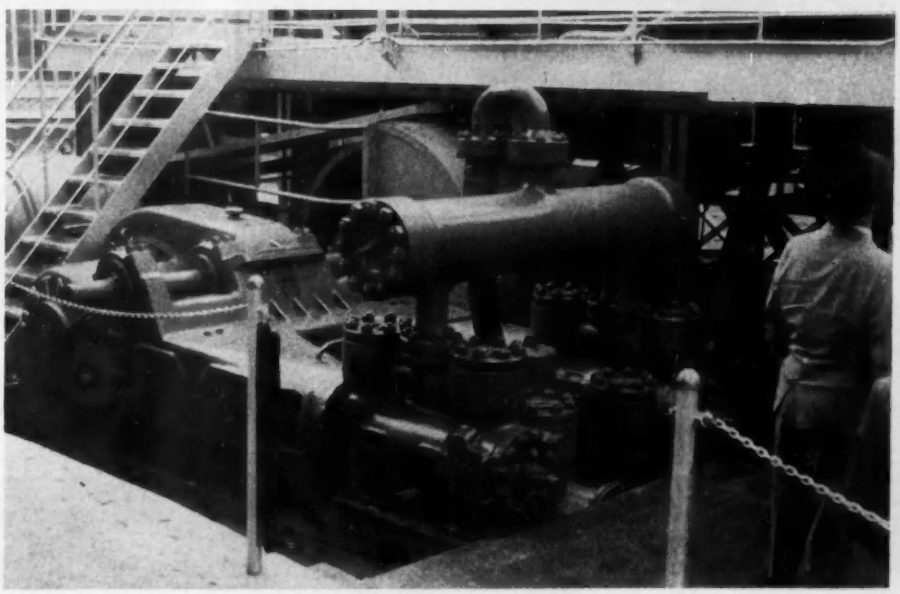




9, 10, 11 In these three photos are shown the various operating positions of the automatic tongs. In the background of Photo 11 is one of the Russian interpreters stationed at the rig.

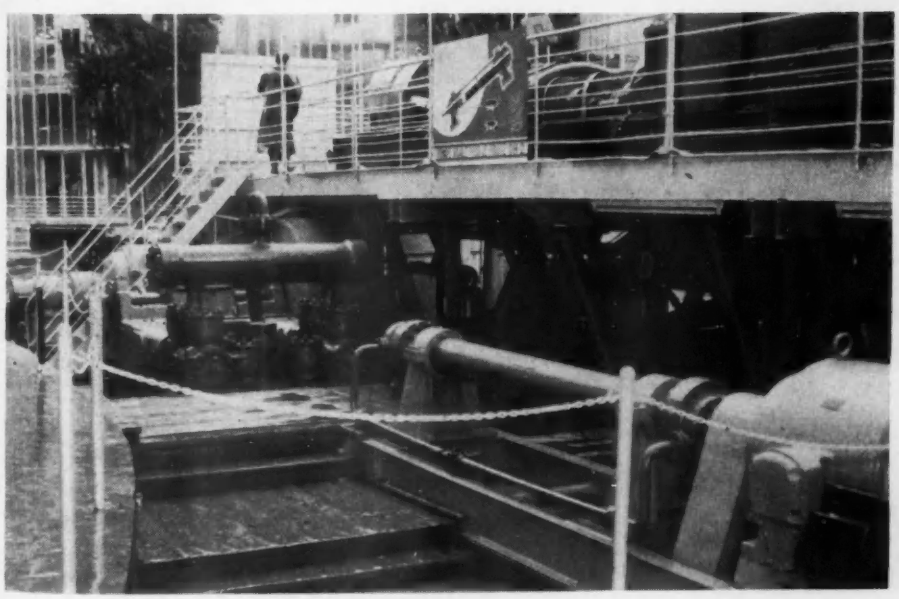


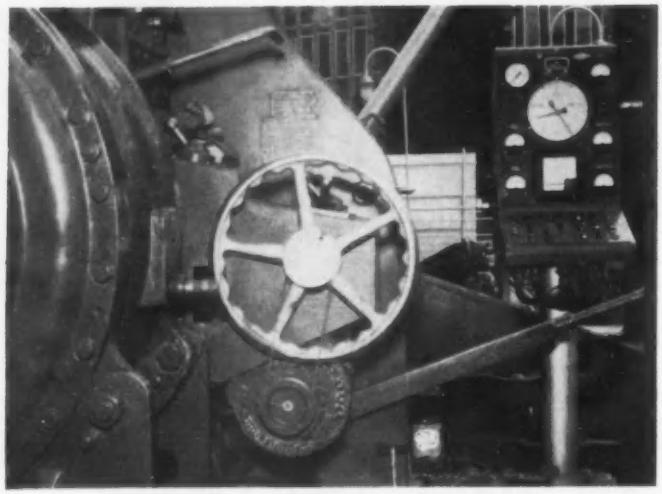
12 (Above) This view from the back of the rig shows the power transmission set up for driving the drawworks and pumps.



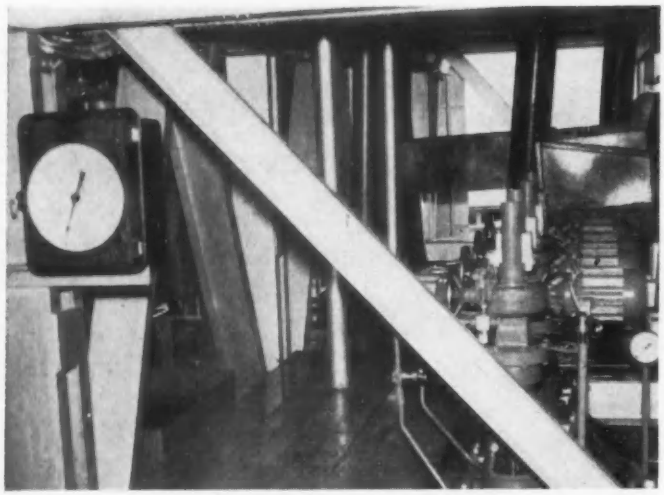
13 (Right) This conventional mud pump has an 8-inch diameter by 18-inch stroke capacity.

14 This view (below) of the axial driven turbine pump which has 32 stages with a rated maximum output of 635 GPM and a maximum working pressure of 400 psi and a minimum working of 200 psi. The minimum rpm of this pump is 1,475. The maximum power of the motor is 140 kilowatts, and the total weight of this pump is 8,800 pounds.

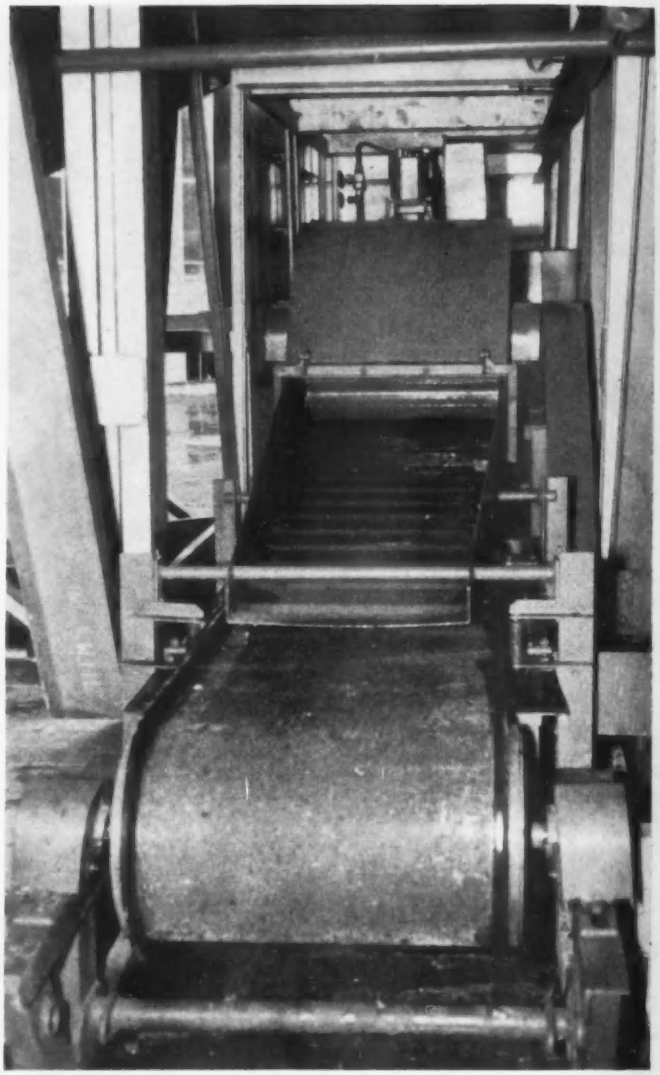




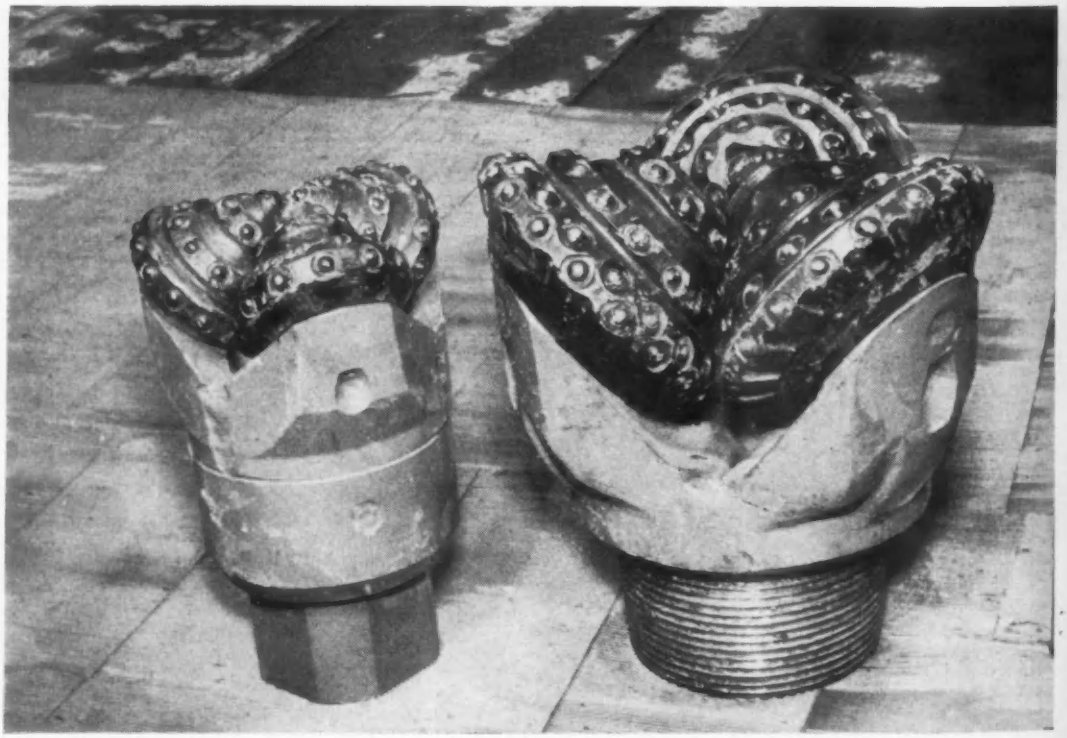
15 Here is a view of the driller's control position showing the various control panels.



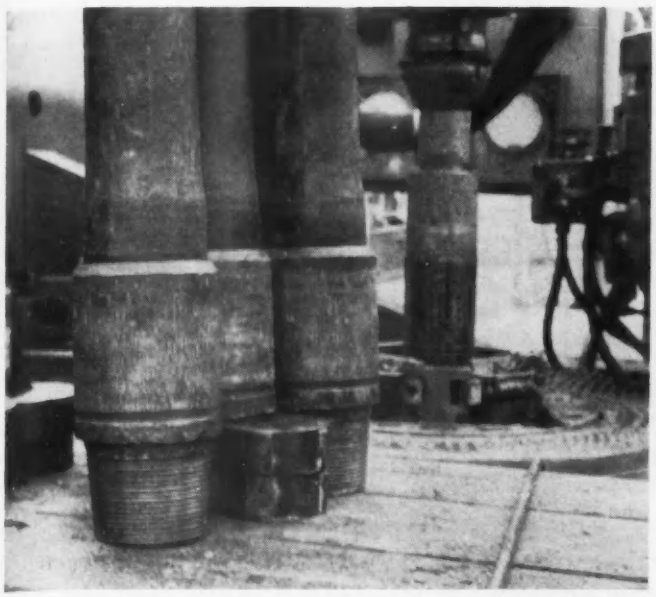
16 This view—from under the rig floor—shows equipment used to measure and control the properties of the drilling fluids.



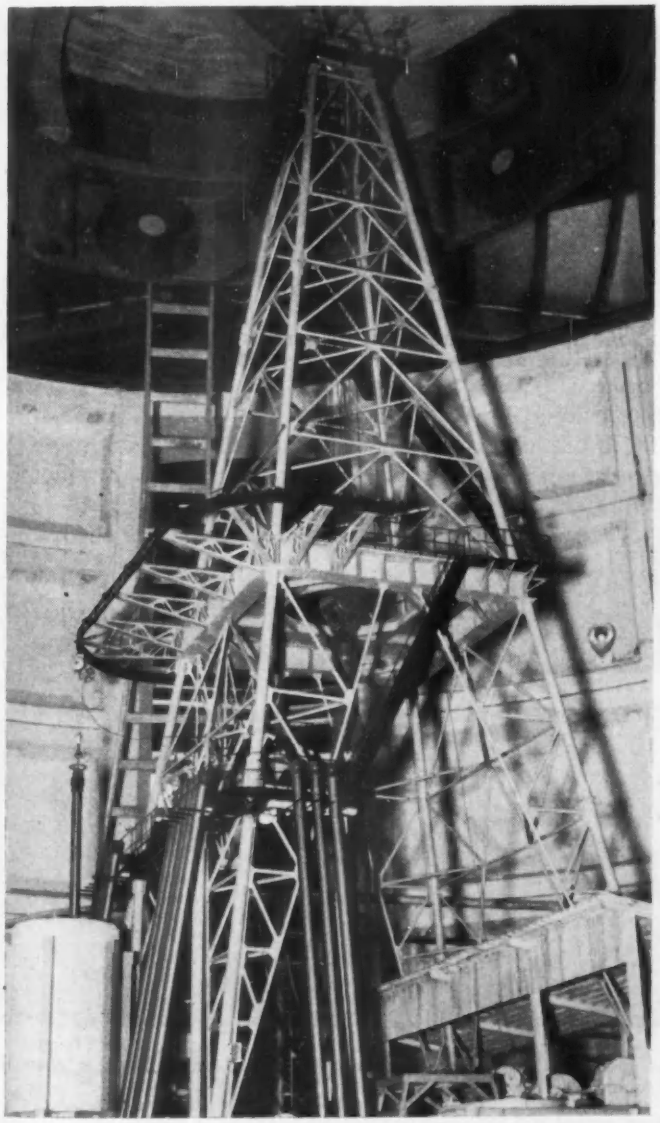
17 The Russians display a new concept in shale shakers. It is mounted securely beneath the rig floor.

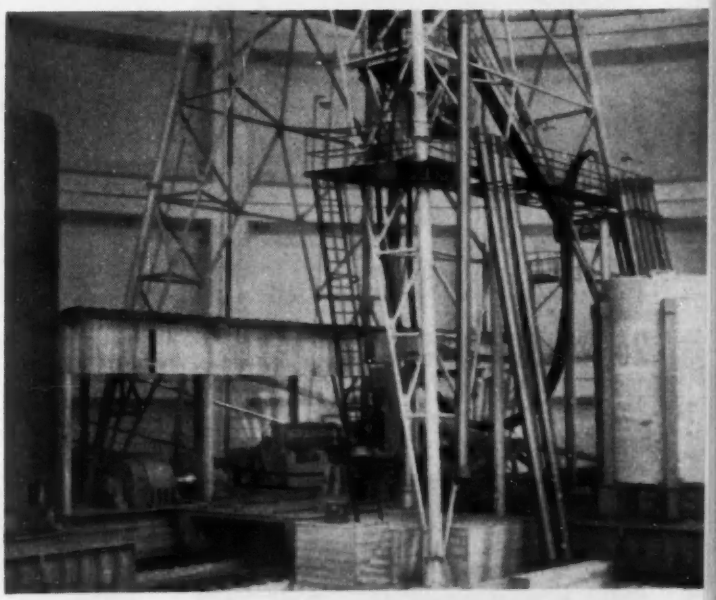


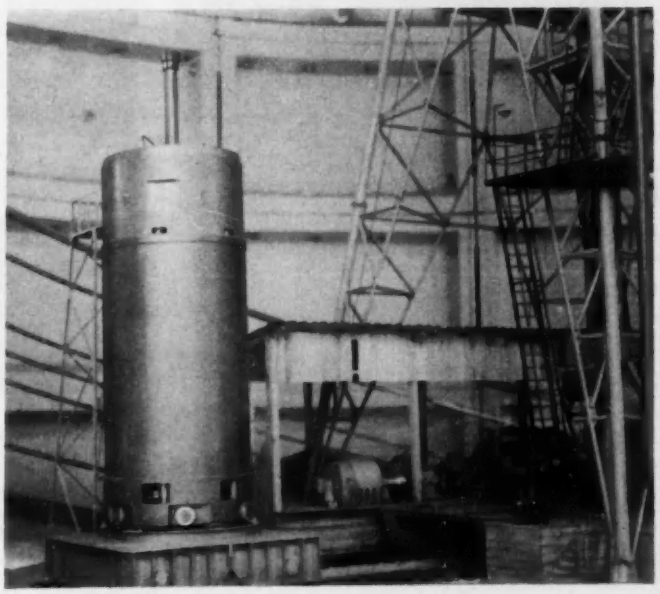
20 These are two of the insert type three-cone rock bits used by Russians in turbodrilling operations. Bits of this type are more commonly used in turbodrilling. The bit on the right is a special type insert bit with a relieved cone bearing design.



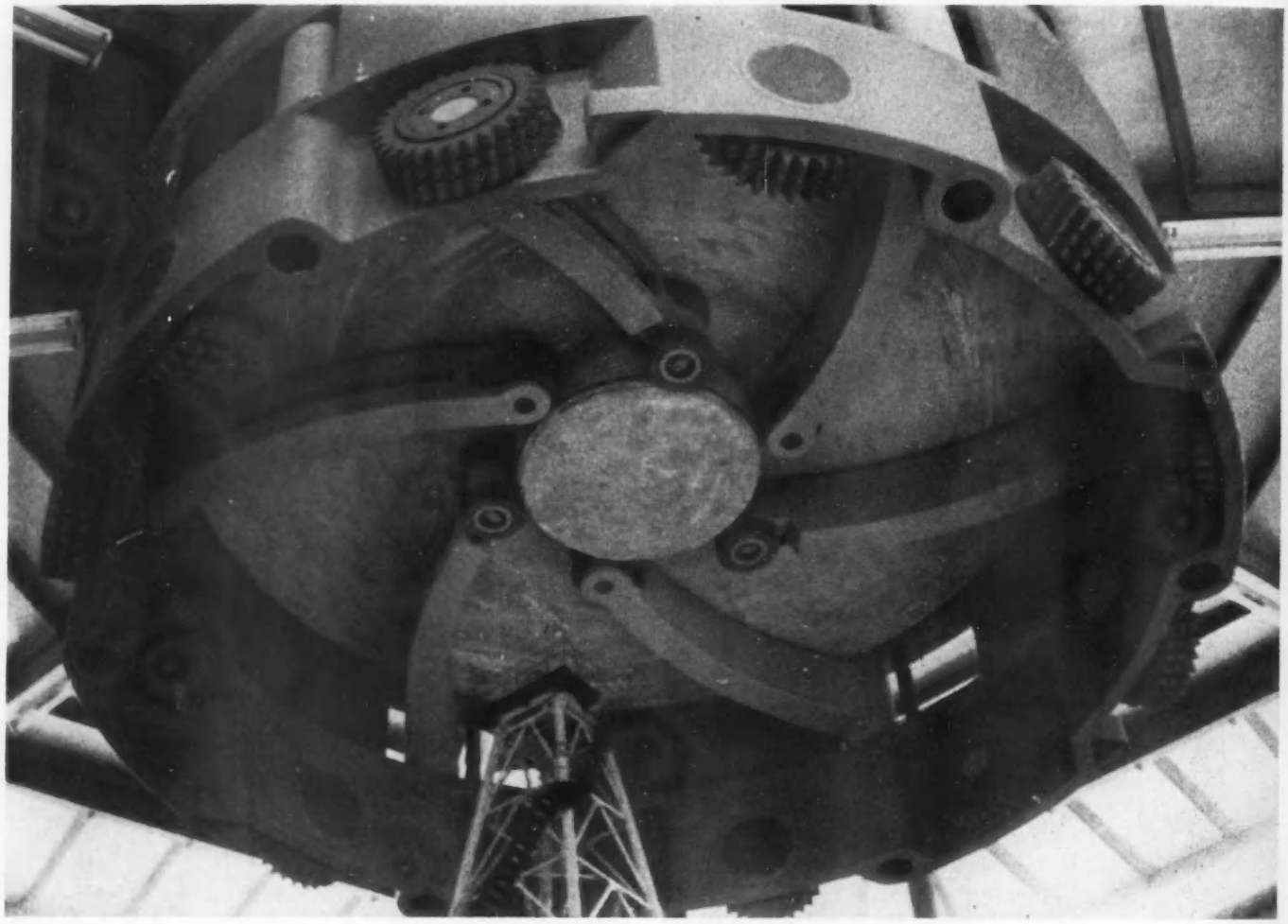
18, 19 These are close-up views of the tool joints on the drill pipe standing in the derrick. The tool joints appeared to be 6⅝-inch regular joints similar to API and the drill pipe was 5½-inch O.D. The tool joints appear to be attached to the drill pipe by a tight fit thread of some design. Tong marks are observed on the tool joints.



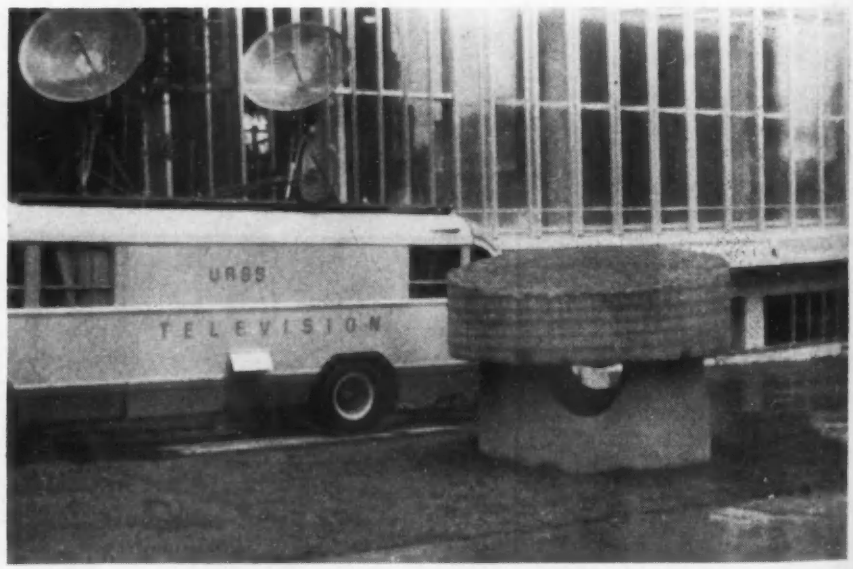




21, 22, 23 These photos illustrate a unique scale model rig used to core drill mining shafts and pits. The rig is operated in a conventional manner except for a track which removes the core after it is retracted from the hole.



24 Full size view of the core cutter head and shows arms which are forced out hydraulically from the main cutter head. Arms have small cutters on the ends which cut the core off in mining operations so it can be retrieved in the core barrel.



25 (At left) As shown in this mock up mine shaft, the cutter head is rotated by large diameter pipe.

26 A section of an actual full size core cut by this method is shown above. This core is approximately nine feet in diameter. The Russians claim that in 1957 a mine shaft in the Donetz coal fields was finished with a diameter of 11½ feet and a depth of 1,000 feet with this equipment. Fifty-five cores each with a length of more than 16½ feet and a weight of 110 tons were removed from this shaft.

A contractor asks . . .

. . . Should I go foreign?

If the answer is "yes," he will find . . .

- **Immediate new opportunities occur mainly in nations where government oil monopolies are now being modified**
- **Labor contracts, becoming rarer, still offer some opportunity to break in on foreign operations without taking big risks**
- **It's almost impossible to make a quick dollar anywhere in foreign operations due to increasing competition and strong nationalism**

BUT

- **Foreign drilling activity is becoming more vigorous, hence it offers more work, more opportunity for those willing to chance the long-term pull**
- **International oil companies are using more contract drillers as their operations expand and as competition intensifies**

By H. T. Brundage, Eastern District Editor

AN INCREASING number of U. S. drilling contractors are entering international operations or are considering this big step. Opportunities exist for those financially and otherwise able to risk the many hazards and pitfalls of overseas work.

Since overseas contracting is so different from U. S. and Canadian operations, there is simply no real substitute for foreign experience. Thus, there is some advantage to starting as soon as possible. Competition is increasing as more contractors go abroad, hence it is doubtful that the opportunity for "green" international drilling contractors will improve in the future.

Contractors must recognize that domestic and foreign drilling operations can hardly be compared—extreme differences exist. New international drilling contractors must learn to overcome a host of unfamiliar problems, such as passport regulations, import and export restrictions and duties, customs, foreign petroleum tax and labor laws, currency and exchange restrictions.

They must use only their most adaptable and self-reliant personnel in foreign operations, especially since communications are difficult and restricted by financial and time considerations. Above all, an international drilling contractor must learn to operate entirely on his own hook. Many services readily available in the U. S. and Canada can be obtained in some countries on a limited basis only, and are not available at all in other areas.

A contractor who may consider a $50,000 spare parts inventory excessive in the U. S. is apt to need more than $250,000 worth of spare parts to support drilling operations overseas. An equal investment for mobile equipment is commonplace for a foreign drilling venture. A drilling contractor moving overseas may need to build extensive camps, involving housing accommodations, medical services recreational facilities; in short, a small city to support drilling operations.

The drilling contractor who might think in terms of doing foreign drilling only for a few years until domestic activity picks up should dismiss the thought. The chances of making a good profit from temporary foreign drilling contracting are slim. This is because a new international drilling contractor is at a big disadvantage in competition with those who have operated internationally for years and who thus have a large backlog of foreign experience.

At the end of World War II, virtually all drilling outside the U. S. and Canada was done with company rigs, and only a handful of contractors ventured abroad in the early postwar years. However, there are now more than 30 U. S. drilling contractors working outside the U. S. and Canada, and these firms are finding stiff competition from western European and other foreign drillers in many places. In addition, governments seem to be getting more nationalistic and generally are placing more roadblocks in the way of any possible windfall profits for foreigners.

On the other hand, an increasing proportion of the wells outside of the U. S. and Canada, particularly wildcats, are being drilled with contract

rigs for the same reasons that contract-drilled wells have become more popular in the U. S.

Canada can be excluded from consideration, because of the general similarity of operating conditions to those in the U. S.

Another major pitfall that is hard to foresee is the hazard of a government changing from encouragement of private investment for oil development to an attitude of discouragement.

An excellent general checklist to be studied has been prepared by Burney Braly ("Interest Grows in Oil's Legal Problems Abroad," WORLD OIL, September, 1957, Page 153). While prepared for producers looking for concessions, many of Braly's points apply to contractors going abroad. Prospective oversea contractors should particularly check the following points:

1. The country's reputation for political stability and keeping its promises.
2. The country's petroleum laws, if any.
3. Avoidance of unlimited liability abroad.
4. Income tax provisions that affect foreign operations.
5. Income and other tax laws of the foreign country.
6. Currency restrictions and repatriation of invested capital.
7. Eligibility of applicant for concessions and equality of treatment.
8. Reliability of previously-done map work and existent geodetic control.
9. Taxes and duties exemptions.

Oil personnel entering a foreign venture become "aliens" and should determine whether they will be welcome and will receive equal treatment with indigenous and other "alien" competitors. Generally, oil personnel should not expect unbiased treatment unless their own country grants equal access to nationals of the country in which they plan to operate.

In most countries, it is best to acquire indigenous legal counsel, particularly in tax matters. The general level of ability and integrity of lawyers throughout the world is high. Ruinous foreign legal judgments can be avoided by a corporation through operating a subsidiary licensed to do business in the foreign country with minimum capital to enable it to be so licensed.

Many governments are loathe to see imported capital leave the country, and legal restrictions on expatriation of capital and profits exist in most countries. Usually, there is a legal limit to the percentage of capital and earnings that may leave the country in any one year.

Labor contracts. A contractor who agrees to supply experienced rig personnel, often tool pushers, drillers and roughnecks, for a foreign operation for a fixed period at a fixed rate of return (usually 5 percent) may provide work for some of his employes who might otherwise be laid off, though obviously such an approach can do nothing to mitigate the problem of idle rigs.

However, both the contractor and his men can learn some of the problems involved in foreign operations in this way while incurring little or no risk.

However, this type of labor contract is becoming rarer. Major company attitudes on such contracts differ considerably. Some dislike them, claiming that labor contract personnel tend to neglect and abuse company equipment. A major company operating in the Middle East reported good results from an incentive-type labor contract, through which drillers and tool pushers are brought from the U. S., combining with Dutch derrick men and native floor roughnecks to complete drilling crews. U. S. derrick men wanted for foreign work sometimes are in short supply, apparently because many good derrick men become drillers.

The trend in foreign operations is away from labor contracts and toward as complete a turnkey job as the major companies can acquire from a drilling contractor. However, the labor contract is not extinct in foreign drilling operations.

Contractors planning to engage in operations abroad should watch for countries which may become more receptive to private capital from abroad. In addition, they should note the increasing number of oil companies going abroad. Another possibility is to watch the granting of new concessions.

Though contracts vary greatly, drilling contractors usually are responsible for the rig, drill pipe, blowout preventers and all other material and services necessary to maintain a rig, while the operator is responsible for all "expendables" such as drilling mud, rock bits, casing, tubing and other completion equipment as needed.

The trend is toward saddling the contractor with the responsibility for providing base camps, roads and, in some cases, beaching and/or port facilities. Despite the trend, contractors should avoid responsibility for as much material as possible. It recently took a month to get a pumping unit through customs in Turkey to allow production tests. In Sicily, rock bits were being worn out faster than new bits could be moved through customs. The greater the responsibility to provide necessary materials, the greater the hazard of delay.

Personnel factors to consider. Selection of personnel is an important factor. Technical competence is only a part, though an essential one, in qualifying for foreign work. The ability to get along and work with foreign nationals is equally essential.

Contractors going abroad must be extremely careful to choose personnel who can get along with all types of people and situations and who show maximum self-reliance in resolving technical operating problems in emergencies with a minimum of outside help. If wives and families are to be sent abroad, too, it is wise to include the applicant's wife in the interview, so that problems of living in a foreign country can be considered by both before a decision is made.

Personnel going abroad must accept the idea that foreign cultures and ways are as good as their own. They must erase any conviction that their way is "superior," while remembering that it is apt to be entirely different. Personnel must learn the appropriate foreign language as rapidly as possible. They should respect the culture, customs and heritage of a foreign country to which they travel *(as a guest)*. This is not only good business, but also the experience is more apt to be pleasureable and interesting if this attitude is adopted. Some large overseas contracting firms sponsor orientation courses for their employes preparing to go abroad.

A contractor should send his most competent, stable and reliable employes who may be depended upon to conduct themselves in a manner which will earn the respect and friendship of people who may not be too friendly.

Working through local contractors has many advantages

Some contractors hire only unmarried personnel. Others accept family men on the understanding wives and children will follow in a year or so, or provide for frequent vacations and free transportation home. These considerations boil down to what a contractor can offer his employes and keep his bids competitive and profitable.

Some contractors feel it is best to work men hard over long periods, perhaps on 12-hour shifts for seven days, then grant three or four days off. One official commented that he had no morale problems until he granted crew members a day or two off weekly in a location where it was impossible to see their families and return in the time allowed. The old Army morale maxim of keeping men busy applies to operations where locations are remote.

It is best to keep the same crews intact as much as possible. This is more important than at home, particularly where language problems and other considerations exist that are not encountered at home.

Local relations. Public and industrial relation problems are apt to be much more complicated abroad. All problems of operating in a foreign country do not end upon reaching agreement with appropriate central government authorities. There must be close accord with local authorities and with local people. So it is best to call on local labor officials when moving equipment through their areas of authority to be sure they understand what is being done and that their authority is respected, regardless of the thoroughness of previous negotiations at the national level.

A particularly tactful approach should be taken with officials of national oil monopolies, especially where previous authority now is being shorn in the interest of more rapid oil resources.

Bear in mind that some foreign oil monopolies previously had much more authority and a much larger area (usually the whole country) as their exclusive domain. Their personnel are apt to be touchy about losing authority and may be difficult to work with in some cases. In some countries any monopoly is looked upon as bad, but many others do not share this feeling.

Generally, recognition of national and local customs, heritage and religions is essential to winning friendship and cooperation in a foreign country. It is important to learn of national and religious holidays, and to grant personnel time off accordingly. Any attempt to impose a different type work schedule on foreign personnel is apt to cost more money than it saves.

Like operations anywhere, operations can work much more smoothly if interest is taken in local problems and works. It may be very advantageous for a drilling contractor to dump a load of gravel into a mudhole in front of a public building in a small town near his rig, or to use temporarily idle mud pumps to clean out a flooded church. Completion of good water wells almost anywhere not only is in the public interest, but also may be directly in the contractor's interest. In arid areas, completion of a good water well may be more important than a good oil well.

Import regulations should be checked thoroughly. Be sure not to import any commodities that can be purchased locally to support indigenous industry and/or to comply with the law. One company ran afoul of the Turkish law by including a nominal amount of table salt. Such items may seem trivial, but government officials may view such violations seriously. Generally, nations discourage importation of goods that compete directly with domestic industries.

For example, Venezuela has prohibitive import duties on many household effects, such as mattresses. Sometimes, high duties are effected only in the vague hope that they may give rise to a domestic industry. Therefore, it should not be assumed that such an industry necessarily exists.

Working with local contractors. It is best to employ local contractors and their personnel for roadbuilding, location clearing, ditching and any other service that they can possibly perform competently. Local contractors' services usually are essential to some degree.

Less equipment, much of it heavy, and fewer personnel will have to be imported and, later, exported. Responsibility for payment of wages, any social security or other compensation falls on the local contractor, rather than on the drilling contractor. Employment of as much native help as feasible is bound to help the local economy and to win friends, provided his dealings are fair and aboveboard.

Use of local contractors also is a way to dispose of payments that may have to be taken in local currencies. Thus, it may be possible to take more payment in local currency if such an approach is necessary to keep bids competitive.

This aspect is so important that in some cases it may be wise to set up a prospective local contractor in business. A local would-be entrepreneur with a reputation for ability and integrity might be short of capital.

Wages and personnel. Ordinarily, it is necessary for a contractor to offer higher wages than are paid domestically to induce a desirable employe to go abroad. It is also advisable to pay indigenous personnel a good salary, though a contractor should not, in both his own interest and in the country's national interest, pay salaries that tend to disrupt local wage scales.

Inherent in this situation are great disparities in the pay scales of different companies. Despite all efforts that oil personnel from any given country may make to avoid giving the impression of assumed superiority, one such employe inclined to brag about the money he is being paid can nullify any and all efforts on the contractor's part to win local good will. One major international oil company's remedy for such occurrences is to fire immediately any expatriate employe caught discussing salary within earshot of indigenous personnel.

Considerations in making bids. The drilling contractor generally must show thorough understanding of conditions in bidding on foreign drilling

Operations outside U.S. demand the best equipment

contracts. From the contractor's viewpoint, it is probably better to contract with a firm with previous foreign experience, from which a contractor may benefit and be in better position to avoid the lesser known pitfalls that may await him in a foreign country. However, major companies dislike to have to "wetnurse" a contractor, and dislike worse to have to bail him out of a contract that proves ruinous.

Drilling engineers of major international oil companies will not consider a bid so low that the contractor cannot possibly make a profit. They know a contractor stuck with a suicidal bid is apt to cut corners desperately and cause the client to lose money due to poor performance.

In addition, company engineers dislike to have to spend time in conference convincing management that the company should not accept the lowest bid if it is tendered at a suicidal figure for the purpose of breaking into the foreign drilling business. A contractor who does this is apt to be overlooked the next time requests for bids are sent out. It may even be unnecessary to overlook him, since one catastrophic foreign job may be enough to put a contractor out of business.

Currency considerations. Most companies operating internationally generate sums of different currencies, including "hard" funds such as dollars and sterling, and "soft" ones such as Turkish lira. Disposal sometimes is a problem. Accordingly, companies do not always accept the lowest tendered bid, but might favor a contractor willing to take a high proportion of his payment in a specific currency, particularly if the company involved happened to have a surplus of that currency. The problem of disposal then falls on the contractor.

Only in the U. S., Venezuela, Switzerland and Portugal can currency generally be exchanged freely. All other nations control currency exchange more or less strictly. Professional help and advice in currency matters often is essential in foreign work.

However, procurement problems are growing less serious as an increasing number of foreign manufacturers —including British, West German, Japanese and others—are complying with American Petroleum Institute specifications, and as more U. S. suppliers form foreign subsidiaries to manufacture equipment identical to that made in the U. S. Though many oil field items are unavailable in many countries, the supply situation is improving, and the variety of currencies that may be used to acquire them is becoming more widespread.

At any rate, currency considerations cannot be ignored. Some countries (e.g., Colombia) impose special duties to allow heavy equipment out of the country. An underdeveloped country generally dislikes to part with obvious assets. It may be possible for a contractor to find himself with a rig in a foreign country, without any work for it, unable to get it out without paying prohibitive duties, and unable to sell it to anyone for currency that he can convert to dollars.

Equipment. Since a drilling rig being sent abroad generally must be totally self-sufficient, the best equipment to take generally is the newest and most expensive. Many foreign jobs available to contractors are for deep, thorough wildcats in remote areas, involving shipment of about 1,000 tons of equipment. Obviously, lighter equipment capable of doing an equally good job is in great demand, and development is being pushed by supply firms.

The trend is toward more specialized rigs. As the locations get more and more remote, airborne rigs will be more in demand. Some foreign locations, particularly in rain forest areas, are more accessible to a mobile drilling barge than to a conventional rig.

As helicopters with heavier effective pay loads are developed and as a greater variety of rigs are designed and manufactured that may be broken down into helicopter-load components, these rigs should become more popular in many areas.

More offshore drilling will be done abroad in the future. Here, again, emphasis is being placed on special rig design.

A hint that may help some drilling contractors is more emphasis on stratigraphic drilling overseas, perhaps on joint account of a number of companies. Geophysical work, especially seismograph, is more expensive abroad than at home, and without sufficient wells abroad for velocity checks and correlation, the value of core tests may be more valuable in certain foreign areas than at home. Hence, core drill programs are a possibility for contractors in some areas.

The emerging prominence of airborne rigs may behoove a drilling contractor to seek a tie-in with an indigenous airline of air charter service in the country where he drills. Faster transportation and communication needs will cause him to use aircraft more often, anyway; and this is another opportunity to engage, in effect, a local contractor.

U. S. regulations. The following regulations are specific requirements which face a U. S. drilling contractor moving into operations abroad. Similar requirements exist, in varying degrees, in other countries.

- Passports. The Passport Office of the Department of State issues passports to U. S. citizens and other persons owing allegiance to the U. S. Passport applications may be made before a clerk of a Federal court or a State court authorized by law to naturalize aliens, or before an agent of the Passport Office. Passport agents are located in Boston, Chicago, Los Angeles, New Orleans, New York, San Francisco and Washington. Passports may be issued routinely in less than two weeks, or in a day in cases of emergency, subject to confirmation by telephone to Washington and an extra fee to cover same.

Passports are not required for persons visiting most Caribbean (including Venezuela and Colombia) and Central American countries. A tourist card will ordinarily suffice for long enough periods to enable a contractor to examine a prospective drilling deal in one of these countries, though a passport would be essential for any business of a more prolonged tenure.

- Export licenses. Requirements ap-

plying to shipments to foreign nations are handled by the Bureau of Foreign Commerce, Commerce Building, Washington 25, D. C. To export equipment, it generally is essential to show that the material is acceptable in the foreign country of destination.

There also are requirements to further advise the Foreign Commerce Bureau if the material is later transshipped to a second foreign country. Such regulations are intended to keep strategic exports from winding up behind the Iron Curtain, but are becoming less stringent. An export license recently was granted to a manufacturer to send a new rig to Poland.

• Shipping problems. Elaborate boxing, usually including waterproofing, of material to be exported is essential to foreign drilling operations. Though it may be possible for the operator to undertake this operation himself, many drilling contractors employ the services of experienced shipping companies and/or agents for pickup, storage, crating, waterproofing, marking, listing and insuring of a shipment for export.

Obviously, these companies' services do not come cheaply, but it takes a beginner many years to match their experience, particularly in the intricacies of import licenses and restrictions in the country of destination.

Primary emphasis in preparing overseas shipments is put on how it must be handled between the foreign port and the final destination. Shipments must be packaged in accord with customs regulations. Shippers must recognize that loading facilities at a foreign railhead may be inadequate or that crews may be inexperienced at handling very heavy unwieldy items.

Shipments to Bolivia, for instance, to enter via Argentine railways, must be in crates that will clear restricted trestles, and must thus "fit the keyhole." Loads must not be so heavy as to collapse poorly maintained bridges and trestles. Packaged items destined for eastern Bolivia should not be in weight components of less than 300 pounds, lest primitive Indians walk off with them. In some primitive areas, the pilferage danger may dictate the need of welding equipment into steel boxes. —**The End**

Contractor's Future

Continued from Page 136

Technology at Odessa, Texas, and the new course on Blowout Prevention and Control, for example. We can make available the Toolpusher's Manual, Safety Manual and drilling mud handbook.

If we can hold our responsible and experienced drillers and crewmen in the industry, and continue to add new technicians, we will be able to field efficient crews. This is a must, to assure the contractors' future as the industry that drills nearly all the world's oil wells.

There is another group that each drilling contractor must consider while contemplating his own future—his competitors.

As long as we exist in what the economists call a state of "pure competition," we will each have to keep an eye on the other fellow. That does not necessarily mean that it will have to be a suspicious eye—merely observant.

There are a great many benefits to be gained from keeping up with what our competition is doing. The easiest way to keep up is to take part in the activities of our trade association, the American Association of Oilwell Drilling Contractors. The AAODC provides the forums for exchange of technical and economic information, and spearheads study programs that will help all of us be better businessmen and artisans.

There has never been a time in the history of the drilling business when it has been so important to each contractor to pay intelligent attention to the over-all affairs of his industry.

The job of the AAODC is to help the individual contractor help himself. The association will throw the ball, but the contractor has to get in the game before he can catch it and run with it.

Contractors must be on guard against self-delusion. By close attention to detail, participation in AAODC activities, and hard work, we can stay in business. But there is no Moses to lead us out of the wilderness. There is no Merlin to change scrap pig iron to gold.

The final answer for each contractor lies in his own response to the challenge of rough going. —**The End**

How good a driller are you?

A quiz for oil field folks. Score as follows: 0-4 (Weevil); 4-8 (Mud Doctor); 8-10 (Expert). One point for each correct answer.

1. Lime base muds have proved to be unsatisfactory at times as a drilling fluid because:
(a) they are not resistant to contamination (b) they tend to gel or solidify in deep hot holes (c) they cannot be weighted-up.

2. A high pH mud is usually safer to use because it contains no caustic. True or false.

3. Which one of the following is not a geological period?
(a) Tertiary (b) Ostracoderm (c) Ordovician.

4. Pumping requirements at shallow depths call for low pressure-high volume. True or false.

5. Match the following part with its parent:

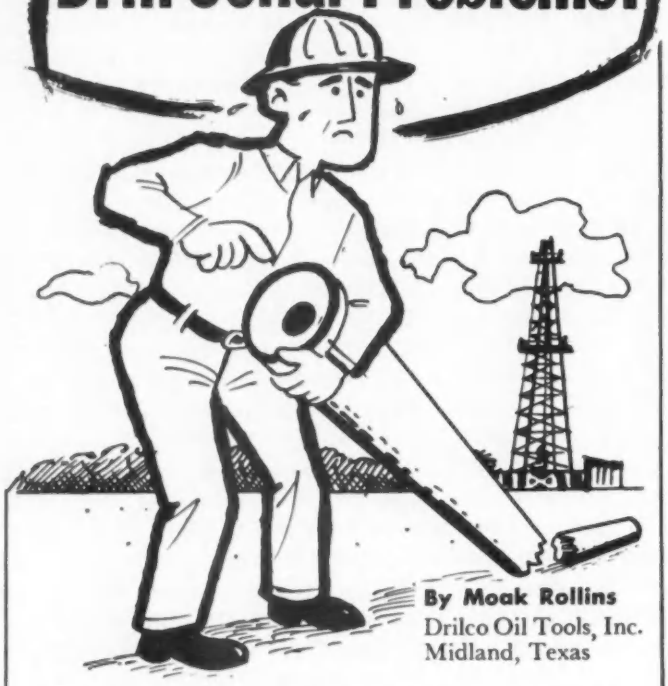
(a) derrick	1. . . . . liner
(b) mud pump	2. . . . . screen
(c) shaker	3. . . . . rams
(d) blowout preventer	4. . . . . jets
(e) bit	5. . . . . girts

ANSWERS

1. b; 2. False; 3. b; 4. True; 5. 1-b; 2-c; 3-d; 4-c; 5-a.

HAVE YOU GOT

Drill Collar Problems?

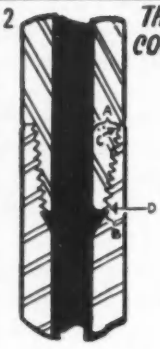


By Moak Rollins
Drilco Oil Tools, Inc.
Midland, Texas

This is the last of three articles explaining pictorially the most common causes of drill collar failure.

2

THERE ARE USUALLY SEVERAL JOINTS WHICH COULD BE SELECTED FOR CERTAIN DRILL COLLARS.



It is important to select the best balanced joints so that in service you do not have excessive pin failures or excessive box failures. Experience has shown that if the wall section in the pin at the first engaged thread (A) is about the same thickness as the box at the end of the pin (B), the joint has a fair balance. A more exacting way to check balance is to calculate the bending strength for the thread root at (C) and at (D). For a well balanced joint it has been determined that this ratio should be: $\frac{\text{Bending strength at (D)}}{\text{Bending strength at (C)}} = 2.25 \text{ to } 2.75$

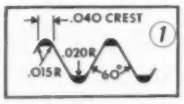
If rapid wear of the collars is expected, the joint should be selected to give extra strength to the box.

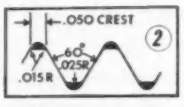
3

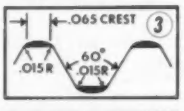
SOME THREADS ARE BETTER SUITED....

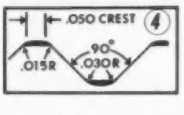
than others for drill collar service because there is less "notch effect" at the thread root.

The API V-.040-inch thread (1) form used on 2⅜-inch through 4½-inch API Reg. joints and on 3½-inch and 4½-inch API F.H. joints—and the API V-.050-inch thread (2) form used on 5½ and 6⅝-inch API Reg. joints and 5½ and 6⅝-inch API F.H. joints—have sharp thread roots and give poor service as drill collar joints.









Better drill collar service can be obtained with the API V-.065-inch thread form (3) used on all IF, extra hole, slim hole, double streamline, and the 4-inch FH joints which were designed for drill collar service.

Lathe operators must be careful to grind their tools to produce the correct thread form. Sometimes they use a tool with a sharp point, or with sharp corners, and produce a thread with sharp notches at the thread root. Cracks will start at sharp tool marks.

Threads cut with a hob on a thread mill usually have correct thread form, because the hob thread form is correctly shaped when the hob is made.

4

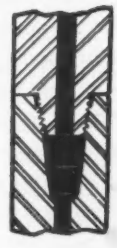
NOTCH EFFECT...

can be minimized and joints made more flexible by removing material in the pin, and in the box.

If these relief grooves are finished with large radii in the corners, and with smooth surface finish—the joints will be made stronger by cutting out some of the material.

BECAUSE relief grooves remove unnecessary threads which are stress raisers, and make the joints more flexible—which spreads the bending over more length—and reduces the bending stress.

Another stress relief form for boxes is the "bore-back" which is a long cylindrical bore in the bottom of the box. The box threads fade away at the end of the pin—an internal vanishing thread.



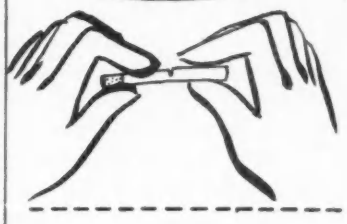
5

COLD WORKING THREAD ROOTS...

...improves their resistance to fatigue cracking by:

1. Improving the surface finish and . . .
2. Prestressing the metal in compression

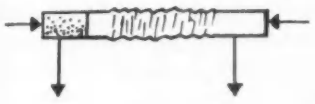
This means the joint can bend farther without stretching the thread root fibers.



TEST THIS YOURSELF WITH A CIGARETTE...

Holding the cigarette tightly—and pulling it slightly, bend it. It will break sharply.

Then, using another cigarette, compress the tobacco and paper toward the center, then holding a slight compression, bend the cigarette. It will bend nearly double before breaking.



Thread root fibers can be compressed by cold rolling the thread roots with a roller ground to the thread contour—or by peening them with an air hammer tool designed to fit the thread root. Cold working can lengthen joint life to as much as three times that of standard joints.

6

Newly machined joints sometimes gall or seize when made up for the first time. To minimize this seizing most manufacturers and field shops coat the joints with a manganese phosphate coating—or with a thin copper plating. These coatings make it easier for lubricants to adhere to the surface and prevent the welding together of the newly machined metal surfaces.

Lubricants used for drill collar joints must be kept clean and protected for blowing dirt and sand. A high quality lubricant containing metallic lead powder or other low friction material is recommended for drill collar joints.

Drill pipe tool joint lubricant is usually not satisfactory as a drill collar lubricant.

HERE ARE SOME SUGGESTIONS FOR CORRECTING SPECIFIC TROUBLE

if pins are breaking near the shoulder in the first or second thread:

LOOK FOR THESE SYMPTOMS	WHICH INDICATE THESE CAUSES
Lapped shoulders or threads, dry pins	Inadequate make-up torque or damaged shoulders
Sharp thread roots	Poor machine shop threading practice
Sharp, deformed threads near shoulder	Excessive make-up torque
Check for high rotary speed	Check joint design for balance

7

IF YOUR BOXES ARE BREAKING ONE OR TWO INCHES FROM THE SHOULDER..

the joint is too large for the drill collar size, and the box is so weak at the shoulder it cannot support the pin.

As a result, the thinner box bends with the pin, instead of preventing the bending. This bending stretches the box thread roots and starts fatigue cracks at this point.

Pin failures—and "dry pins" also accompany this problem.

8

IF YOUR JOINTS ARE CRACKING...

in the box threads at the bottom of the box (at the end of the pin) . . .

LOOK FOR THESE SYMPTOMS	WHICH INDICATE THESE CAUSES
Corrosion pitting in thread roots	Highly corrosive fluid in highly stressed area. Use stress relief groove to minimize effect
Sharp thread roots or sharp corners	Poor machine shop practice
Check joint design for balance	Joint may be too large for collar size

IF YOUR JOINTS ARE LEAKING...

have mud in the threads (dry pins) or are "hard to break" . . .

LOOK FOR THESE SYMPTOMS	WHICH MAY INDICATE THESE CORRECTIVE ACTIONS
Obstructions on the shoulders, fins, galls, wash outs, chain marks	1. File off fins and bevel 2. Repair light galls or wash-outs with facing tool
Damaged threads	Repair with 3-corner file
Indication of lapping (Dull gray areas), dry shoulders, dry pins	1. Increase make-up torque. Measure it with a torque gage 2. Improve cleanliness in handling and make up 3. Use a better lubricant
Box shoulders too thin—joint too big for collar size. Boxes swelled	Check for joint design balance

—The End

A DRILLING PROGRESS FEATURE

How to obtain . . .

Maximum hydraulic power at the bit

As deeper drilling trends are established, continued emphasis is being placed on properly designed hydraulic drilling programs

By R. W. Colebrook,
Development Engineer
The National Supply Company,
Houston

PUMP POWER requirements are steadily increasing on drilling rigs. The 500 to 1,000 horsepower mud systems placed in service a decade ago are being replaced by 1,500 to 2,000 hp systems. Even more powerful systems probably will be used in the future.

This power is being added primarily to increase the hydraulic power at the bottom of the hole. Jet bits have proven that penetration rates can be increased substantially by high downhole power. It now appears that other downhole mud operated devices such as reciprocating motors, turbines or positive displacement rotating motors will be advantageous. These devices will further increase the hydraulic horsepower requirements at the bottom of the drill string.

These developments make important the examination of the means by which hydraulic power is supplied to mud operated devices on the bottom of the drill string. This subject is approached from a theoretical standpoint, and indicates how to get the highest hydraulic power at the bottom of the hole.

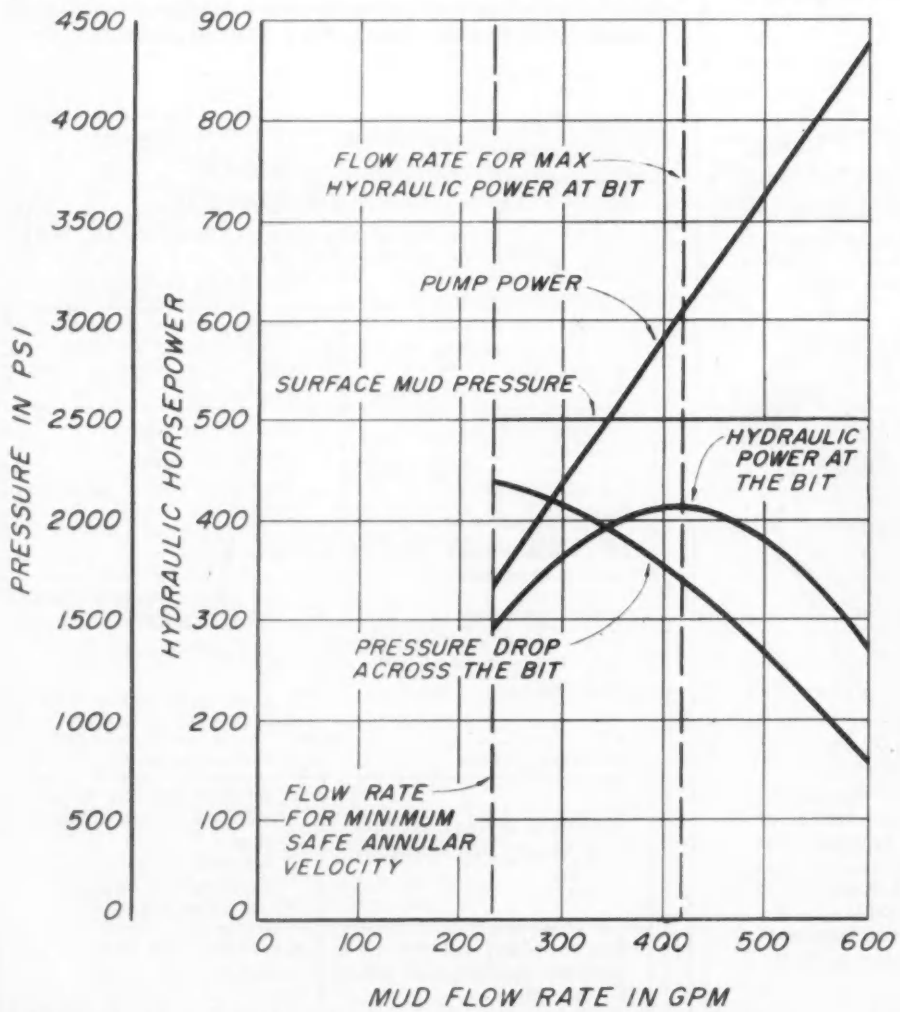


FIGURE 1—Downhole hydraulic power, pump power and pressure drop across the bit will vary with the mud flow rate in an 8¾-inch example hole in West Texas at a depth of 10,000 feet.

Hydraulic power at the bottom of the drill string. The amount of hydraulic power at the bottom of the drill string depends on both the mud system and the downhole device which the mud operates. To get the highest downhole hydraulic power, two conditions must be met.

1. Mud system losses must be reduced as much as possible.
2. The downhole device must be matched to the rest of the system.

Mud system losses are reduced by using tubular material with the largest possible bore and by using the lightest mud hole conditions will permit. The surface mud pressure should be the highest which can be maintained economically, as pressure contributes to the power but not to the mud system losses.

The downhole mud operated device matches the rest of the system when it has the right pressure drop at an optimum mud flow rate. There is a considerable difference in the pressure drop of different devices. An open bit

ACKNOWLEDGMENT

This article is based on a paper presented at the 13th annual American Society of Mechanical Engineers Petroleum Mechanical Engineering Conference in Denver, Colo., Sept. 21-25, 1958.

has practically no pressure drop even at very high mud flow rates. A jet bit with very small nozzles can have such a high pressure drop that the maximum economic mud pressure is reached at a very low mud flow rate. The pressure drop and mud flow rate for the highest downhole hydraulic power are between these extremes.

The best pressure drop at the bottom of the drill string. The pressure drop across the bit or other device on the bottom of the drill string has considerable effect on the downhole hydraulic power.

In West Texas, a rig could be found drilling 8¾-inch hole at 10,000 feet using jet bits. The maximum economic mud pressure might be 2,500 psi. The effects of changing the mud flow rate, while keeping 2,500 psi mud pressure by changing the bit nozzle sizes, are shown on Figure 1. When the mud flow rate is increased pump power always increases. Hydraulic power at the bit first increases with increased flow rate, then decreases. The maximum hydraulic power at the bit occurs when the pressure drop across the bit is about two-thirds of the maximum economic mud pressure.

An approximate equation presented in the appendix, shows that the downhole hydraulic power always is highest when the pressure drop across the device on the bottom of the drill string is about two-thirds of the maximum economic mud pressure.

The conclusions reached from this are:

- A maximum hydraulic power is obtained at the bottom of the drill string with any given hole dimensions, mud weight, drill string and mud pressure limitation.
- To achieve maximum hydraulic power, the device on the bottom of the drill string must be designed to operate with a mud flow rate and a pressure drop dictated by the rest of the system. The pressure drop must be about two-thirds of the maximum economic mud pressure.

The best mud flow rate. The mud flow rate which produces maximum hydraulic power at the bottom of the drill string varies with the dimensions of the drill string and the hole, the weight of the mud and the maximum economic mud pressure.

It is given by the approximate equation:

EQUATION 1A $$Q_{opt} \approx \left[\frac{P_{limit}}{2.9\,K_1}\right]^{0.53}$$

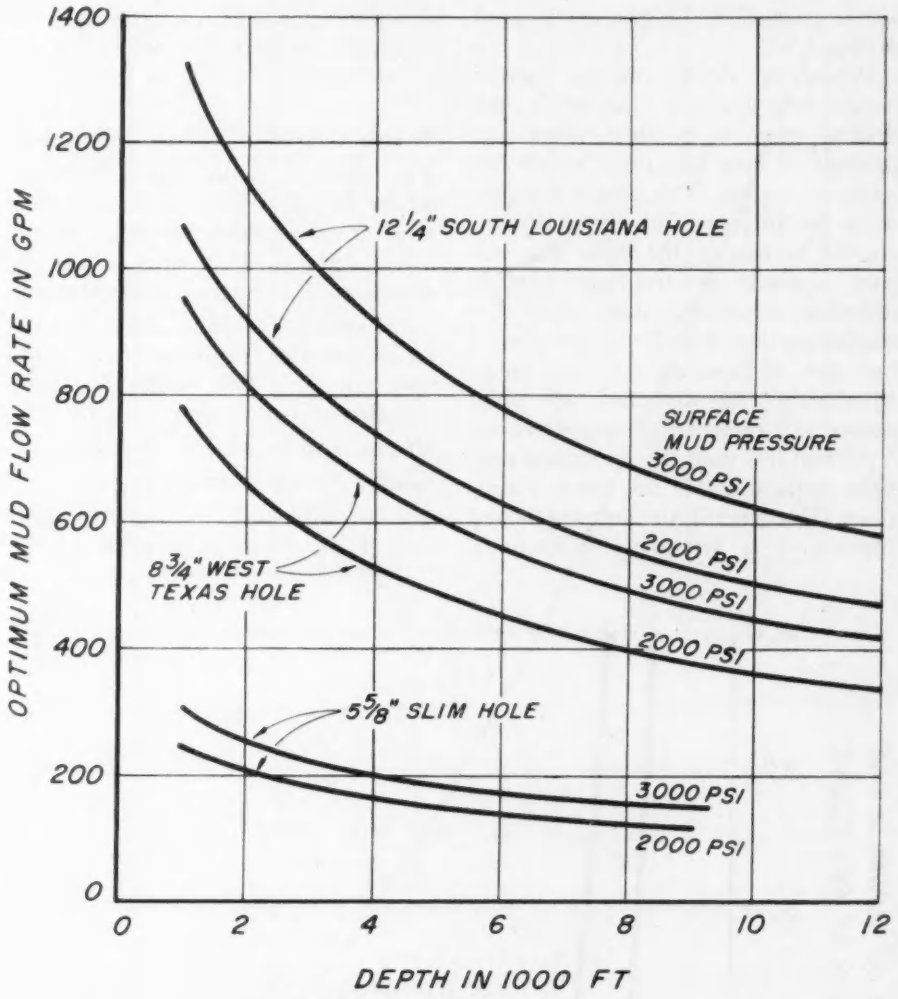


FIGURE 2—Three example wells shows the optimum mud flow rate at any depth with certain given mud pressures.

Where Q_{opt} = Best mud flow rate in gpm
P_{limit} = Maximum economic mud pressure in psi
K_1 = A function of hole and pipe dimensions, and mud weight

The mud flow rates for maximum hydraulic power at the bottom of the drill string for three example holes are shown by Figure 2. The best mud flow rate for a slim hole may be as little as one-fourth of the best mud flow rate for a South Louisiana hole at the same depth using the same mud pressure.

The graph also shows that the best mud flow rate is much greater for shallow holes than for deep holes. In the South Louisiana example hole, the best mud flow rate at 2,000 feet is almost twice the best mud flow rate at 12,000 feet with the same surface mud pressure.

High pump power is required at shallow depths because of the high mud flow rate. The actual downhole hydraulic power is high at shallow depth. This portion of the hole usu-

TABLE 1

Maximum downhole hydraulic power in a 12¼-inch hole at varying depths. (Maximum economic mud pressure is assumed to be 3,000 psi.)

Depth, Ft.	Assumed Maximum Mud pressure: psi	Flow Rate For Maximum Down Hole Horsepower: gpm	Total Surface Hydraulic Horsepower	P Bit: psi	Down Hole Hydraulic Horsepower	Required Nozzle Area: In²	Closest Nozzle Sizes
4,000	3,000	915	1,600	1,960	1,042	.611	2 5/8", 3 1/2"
8,000	3,000	695	1,210	1,960	795	.465	2 11/32", 3 1/16"
12,000	3,000	580	1,010	1,960	662	.388	2 1/4", 3 11/32"

ally is finished in the first few days of drilling.

When the device on the bottom of the drill string is a jet nozzle, the drilling rate is greatest when the product of flow rate times nozzle velocity is largest. This product represents the impact of the mud stream on the bottom of the hole. The impact is made greatest with slightly different conditions than those for maximum downhole hydraulic power, but the differences are not large. Maximizing the downhole hydraulic power will result in an impact about 5 percent less than the maximum possible impact under the same conditions. The general conclusions reached concerning a system for maximum downhole hydraulic power also are applicable to systems in which impact is maximized.

Power transmission efficiency. The efficiency with which hydraulic power is transmitted to a downhole mud operated device is equal to the ratio of the pressure drop across the device to the surface mud pressure.

Downhole hydraulic power is highest when this ratio is about 0.66; with any given hole, drill string, mud weight and surface mud pressure. The efficiency at maximum downhole hydraulic power is, therefore, about 66 percent. Efficiency can be made higher only if less power is acceptable.

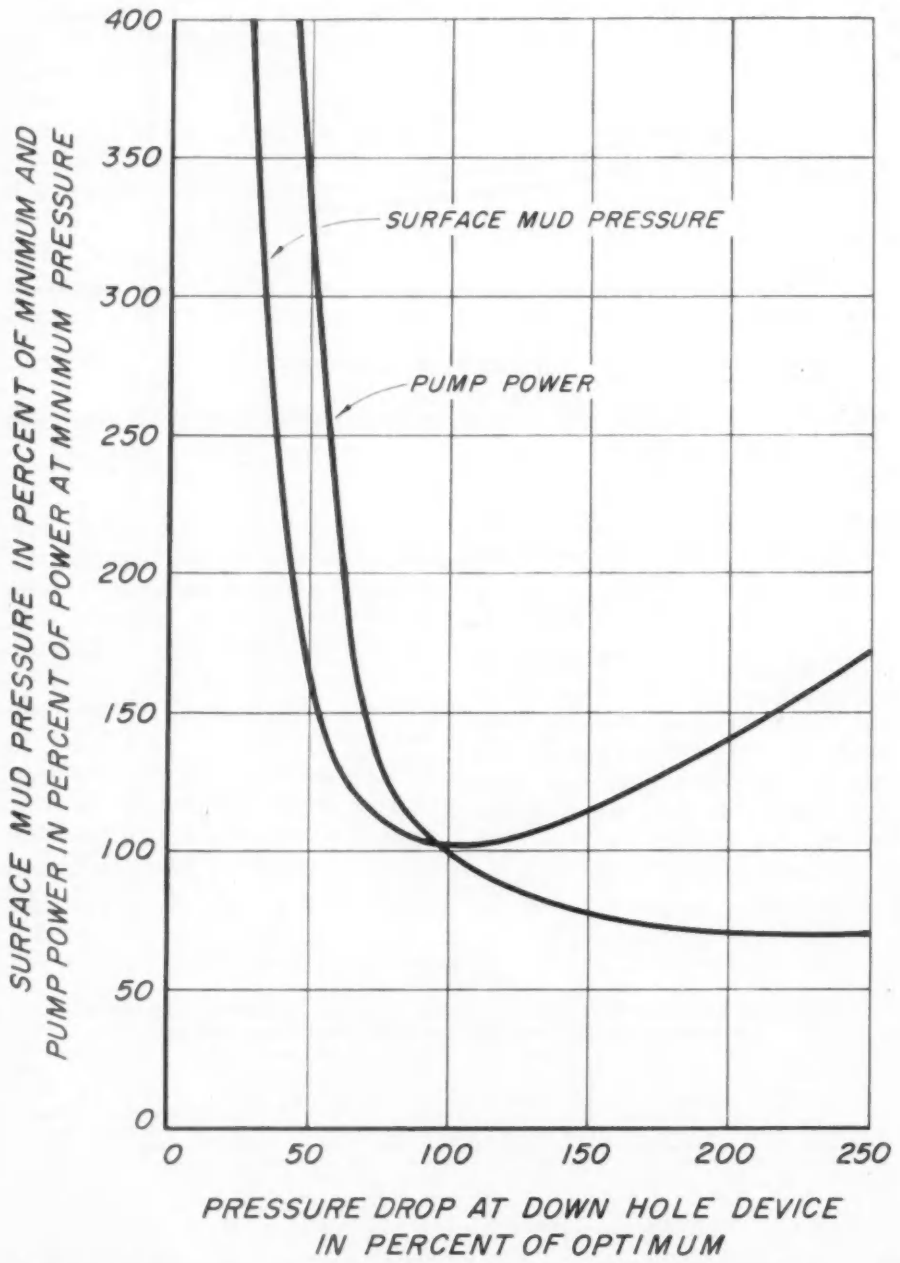


FIGURE 3—When constant downhole hydraulic power is maintained, the surface mud pressure and pump power will vary with the pressure drop across the downhole device.

To make the efficiency higher, it is necessary to use a lower mud flow rate and a downhole device with greater mud flow resistance. The limiting case occurs when the downhole device restricts the passage of mud. The efficiency is 100 percent but the power is zero.

Less than 66 percent efficiency, as well as reduced downhole power, results when the pressure drop across the downhole device is less than 66 percent of the surface mud pressure.

Devices that use the mud power. The best pressure drop across the device on the bottom of the drill string is likely to be constant for intervals of several thousand feet of drilling. The best pressure drop is constant because it is a fixed portion of the maximum economic mud pressure which, in turn, is determined by the pressure rating and maintenance costs of the mud pumps and associated equipment. Changes are not likely except when the pump liner size is changed.

The optimum mud flow rate varies considerably. It is affected by changes in hole depth, mud weight and drill string bore as well as the maximum economic mud pressure.

Therefore, it is desirable for a downhole mud operated device to be designed for a pressure drop which is essentially constant, and for a mud flow rate which varies considerably.

Table 1 shows how well jet bits can conform to this ideal. The tabulation shows the jet bit nozzle sizes and mud pump power needed to get maximum hydraulic power at the bottom of the drill string while drilling the 12¼-inch diameter portion of a South Louisiana type well with 3,000 psi mud pressure. The nozzle sizes required vary from ⅝-inch to 13/32-inch, depending on the depth and the number of nozzles. The required pump power varies from 1,600 hydraulic horsepower at 4,000 feet to 1,000 hydraulic horsepower at 12,000 feet.

These values, which were calculated for the maximum downhole hydraulic power, are very close to those actually used in the most advanced current jet drilling practice. This indicates that the most advanced current jet drilling practice is close to the ideal. The downhole hydraulic power is

nearly the highest possible with the pipe sizes, mud weights and surface mud pressures now considered economic. No further significant increases can be made in hydraulic power or impact at the bottom of the hole without using larger bore drill strings, lighter muds or higher surface mud pressures.

Several devices other than jet bits use the hydraulic power at the bottom of the drill string including reciprocating motors, turbines and positive displacement rotating motors. Whenever possible, these devices should be designed or arranged to conform to the conditions for maximum downhole power. Deviations from these conditions, particularly in the direction of reduced pressure drop, have considerable effect on the surface mud pressure and pump power required.

Low pressure drop mud operated devices. Conditions necessary to get the lowest possible surface mud pressure with any given downhole power are described by mathematical expressions. This expression is the same as for calculating the maximum downhole power. This means that a pressure drop across the device on the bottom of the drill string of about two-thirds of the surface mud pressure will produce the lowest possible surface mud pressure with the downhole power realized.

Figure 3 is a graph showing the surface mud pressure and pump power needed to operate downhole devices of the same power, using the same drill string and mud weight, but with different pressure drops.

As an example, compare the surface pressure and pump power needed when using an optimum device to the surface pressure and pump power needed when using a device with half the pressure drop and twice the flow rate of the optimum device. The graph indicates that a device with half the optimum pressure drop requires a surface mud pressure about 160 percent of that needed for an optimum device. The pump power is 320 percent of the pump power needed for an optimum device.

It is, therefore, desirable for a mud-operated downhole device to be designed for a pressure drop and a mud flow rate as near as possible to the optimum.

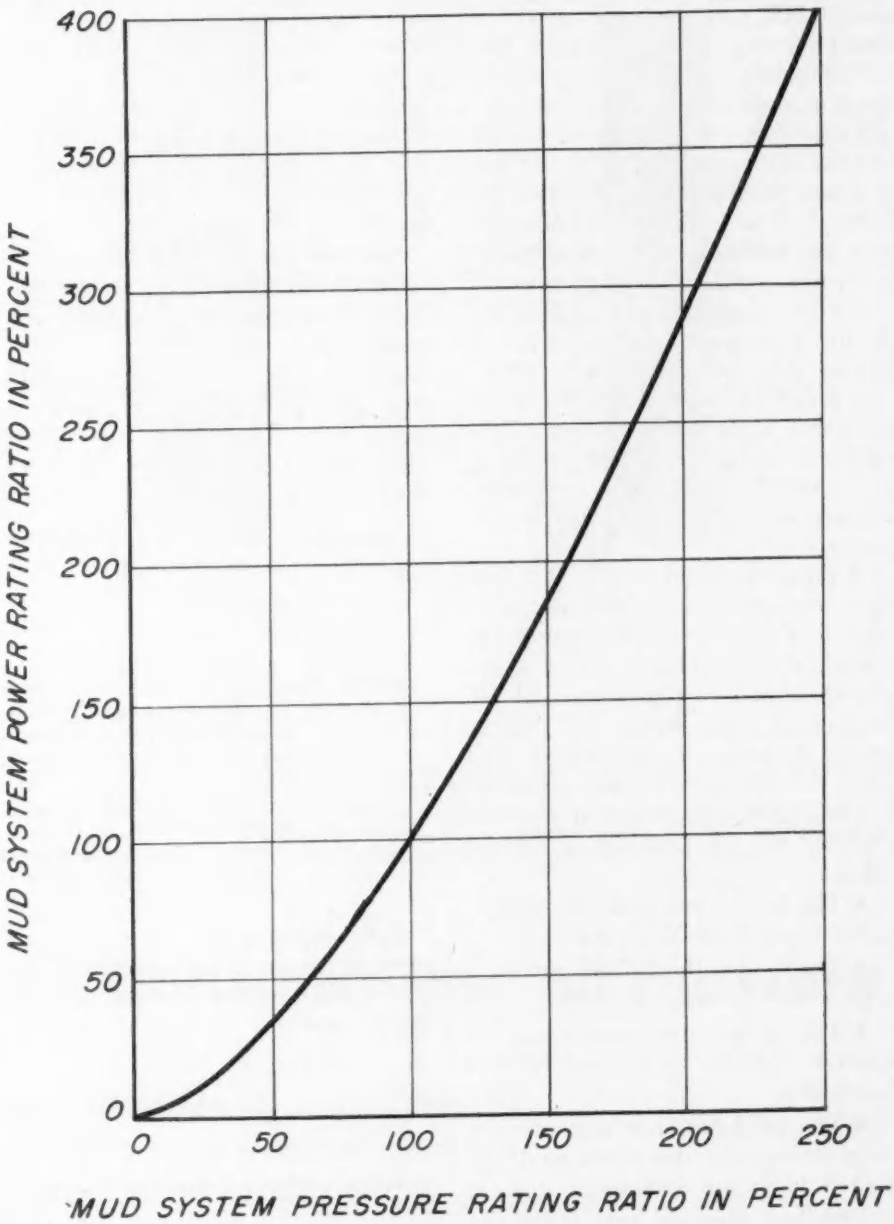


FIGURE 4—The mud system pressure rating will increase with an increase in the mud system pressure. The above chart illustrates this condition when the downhole hydraulic power is at a maximum.

Future pump requirements. Bottomhole horsepower requirement will undoubtedly increase with improved jet programs. This will increase the required pressure and power ratings of future mud systems. The pressure and power ratings needed can be anticipated from the relation of pump power to surface mud pressure for optimum flow rates.

This relation is expressed mathematically by Equation 3A.

$$\text{EQUATION 3A} \quad HHP \approx \frac{(P_{limit})^{1.53}}{K_2(2.9\,K_1)^{0.53}}$$

Where HHP = Hydraulic horsepower of the pump

P_{limit} = Maximum economic mud pressure in psi

K_1 = A function of hole and pipe dimensions, and mud weight

K_2 = A constant relating pressure and flow rate to hydraulic horsepower

This equation indicates that under these conditions the power rating of a mud system should vary as the 1.53 power of the pressure rating. Figure 4 is a graph showing how the pump power changes as the pressure rating is changed. It is plotted in terms of the ratio of power ratings which accompany a ratio of pressure ratings.

If the surface mud pressure is increased to 5,000 psi in a system now

using 3,000 psi, the pressure rating would increase to 167 percent. The corresponding pump power would increase approximately 220 percent.

Table 2 shows the effects of this increase in pressure on the drilling of a hole similar to the hole used for Table 1. This indicates that where a total of 1,600 hydraulic horsepower is needed with a mud pressure of 3,000 psi, approximately 3,500 hydraulic horsepower will be necessary to raise the mud pressure to 5,000 psi.

If downhole mud motors are developed with a pressure drop and a flow rate near the optimum, pump requirements will be similar to those for jet drilling with the same downhole power.

If downhole mud motors with less than the optimum pressure drop are used in the future, pump power required will be higher for a given downhole power. The amount of the increase in pump power will depend on the deviation of the pressure drop from the optimum pressure drop.

Thus, hydraulic power at the bottom of the drill string is highest when:

- The largest practical bore is provided through the drill string.
- The mud is the lightest and stays within safe operational limits.
- The surface mud pressure is the highest that can be maintained economically.
- The mud flow rate and pressure drop across the downhole mud operated device are optimum.

The best pressure drop across the downhole device is about two-thirds of the surface mud pressure, while the optimum mud flow rate is a function of pipe and hole dimensions, mud weight and surface mud pressure.

Good jet drilling practice conforms closely to the above conditions. Therefore, the downhole power used in jet drilling can be made higher than that achieved by present good practice only when higher mud pressures, lighter muds or larger bore drill strings are made practical.

Downhole mud operated devices with a pressure drop higher or lower than the optimum pressure drop require higher surface mud pressure for the same downhole power.

The pump power varies as the 1.53 power of the system pressure for maximum downhole power. Therefore, systems now using about 1,600 hydraulic horsepower with a maximum mud pressure of 3,000 psi, will require 3,500 hydraulic horsepower when improvements allow 5,000 psi mud pressure to be used.

Appendix. The following symbols are used in the derivations.

P = Mud pressure psi
Q = Mud flow rate gpm
HHP = Pump hydraulic horsepower
BHP = Downhole hydraulic horsepower
K_1 = A function of hole and pipe dimensions, and mud weight relating flow rate to pressure drop
n = An exponent relating flow rate to pressure drop
K_2 = A constant relating hydraulic horsepower to flow rate and pressure.

Following is a derivation of the expression for the mud flow rate which gives the maximum downhole hydraulic power.

$$P_{surface} = \triangle P_{drill\ string\ and\ hole} + \triangle P_{bit}$$

$P_{drill\ string\ and\ hole}$ can be approximated by:

$$\triangle P_{drill\ string\ and\ hole} = K_1 Q^n$$

Substituting and multiplying through by $\frac{Q}{K_2}$:

$$\frac{Q P_{surface}}{K_2} = \frac{K_1 Q^{n+1}}{K_2} + \frac{Q \triangle P_{bit}}{K_2}$$

By definition:

$$BHP = \frac{Q \triangle P_{bit}}{K_2}$$

Substituting and rearranging:

$$BHP = \frac{Q P_{surface}}{K_2} - \frac{K_1 Q^{n+1}}{K_2}$$

Differentiating:

$$\frac{d\,(BHP)}{d\,(Q)} = \frac{Q\,d(P_{surface})}{K_2\,d(Q)} + \frac{P_{surface}}{K_2} - \frac{K_1\,(n+1)\,Q^n}{K_2}$$

For maximum BHP:

$$\frac{d\,(BHP)}{d\,(Q)} = O \qquad Q = Q_{opt}$$

When using the maximum economic $P_{surface}$:

$$P_{surface} = P_{limit} \qquad \frac{d\,P_{surface}}{dQ} = O$$

Substituting and rearranging:

EQUATION 1

$$Q_{opt} = \left[\frac{P_{limit}}{K_1\,(n+1)}\right]^{\frac{1}{n}}$$

Following is a derivation of the expression for the pressure drop across the downhole device which gives the highest hydraulic power at the bottom of the drill string.

$$P_{limit} - \triangle P_{bit} = K_1 Q^n_{opt}$$

Substituting for K_1 in equation 1 and rearranging:

EQUATION 2

$$P_{bit} = P_{limit}\frac{n}{n+1}$$

Following is a derivation of the expression for the relation between the pump hydraulic power and the surface pressure.

Multiplying equation 1 by $\frac{P_{limit}}{K_2}$

$$\frac{P_{limit}\,Q_{opt}}{K_2} = \frac{\left(P_{limit}\right)^{\frac{n+1}{n}}}{K_2\,K_1(n+1)^{\frac{1}{n}}}$$

by definition:

$$HHP = \frac{P_{limit}\,Q_{opt}}{K_2}$$

substituting:

EQUATION 3

$$HHP = \frac{\left(P_{limit}\right)^{\frac{n+1}{n}}}{K_2\left(K_1(n+1)\right)^{\frac{1}{n}}}$$

From calculation of the mud pressure for a number of cases, it appears that with any given hole situation the surface mud pressure varies approximately as the 1.9 power of the mud flow rate. Therefore $n = 1.9$.

—The End

TABLE 2
This table shows the same information as Table 1 except a maximum economical mud pressure of 5,000 psi is used instead of 3,000 psi.

Depth, Ft.	Assumed Maximum Mud Pressure: psi	Flow Rate For Maximum Down Hole Horsepower: gpm	Total Surface Hydraulic Horsepower	P Bit: psi	Down Hole Hydraulic Horsepower	Required Nozzle Area: In²	Closest Nozzle Sizes
4,000	5,000	1,200	3,500	3,275	2,290	.621	2 5/32", 3 1/32"
8,000	5,000	910	2,650	3,275	1,735	.471	2 11/32", 3 1/16"
12,000	5,000	760	2,210	3,275	1,450	.394	2 1/32", 3 11/32"

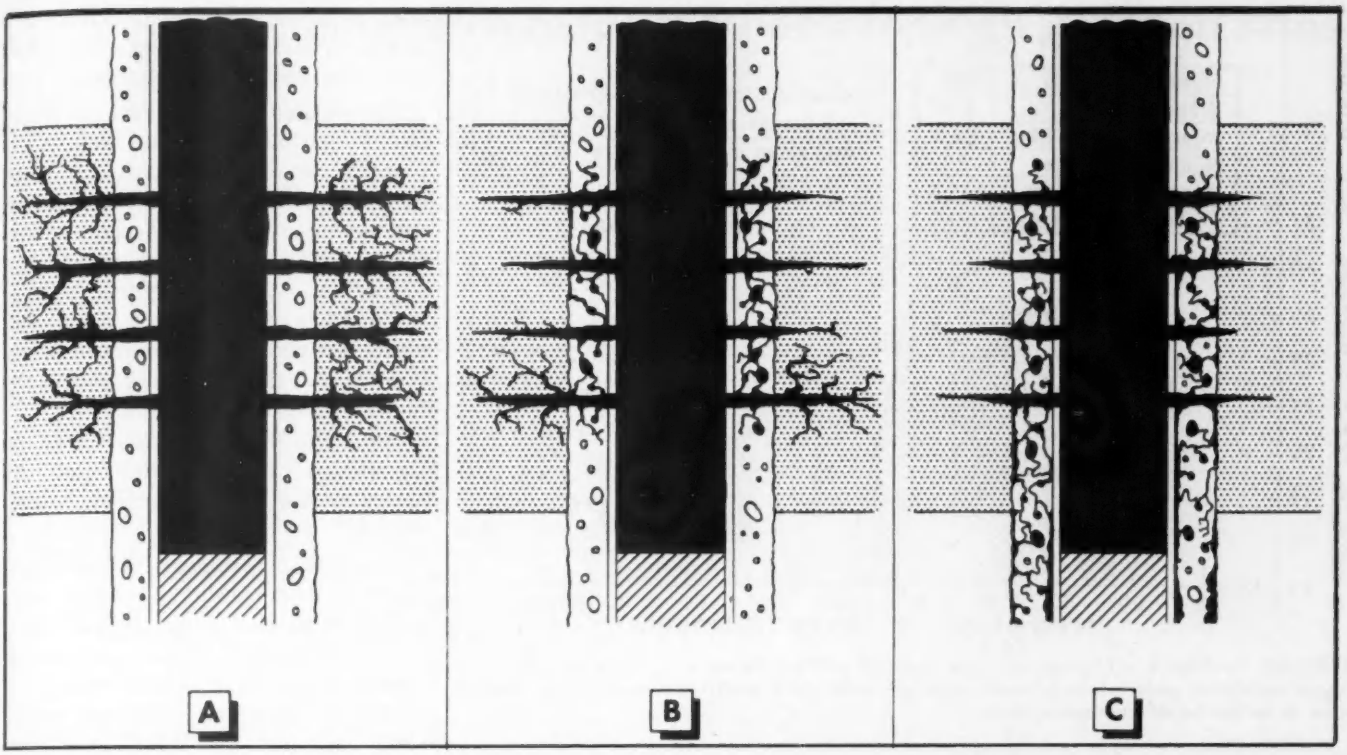


FIGURE 1—The different paths injected fluid may follow are illustrated.

Panel A—This zone is being effectively fractured through each perforation. There is no evidence of communication.

Panel B—Definite communication exists between perforations in this case. Fluid channels between holes. Only 25 percent of the zone is effectively fractured.

Panel C—Communication between zones is indicated in this schematic drawing. Fluid channels down the side of the casing into a foreign zone. The pay zone is not fractured.

Engineered completions increase oil recovery

Selective perforating, reduced shot density and engineered stage fracturing will result in more effective reservoir drainage, more effective use of reservoir energy and greater ultimate recovery. Completion costs can be reduced as much as 25 percent.

By R. W. Coburn, District Superintendent
Champlin Oil and Refining Company, Enid, Okla.

RECENT REVISIONS in perforating and fracturing techniques have resulted in more efficient and economical oil and gas well completions. To obtain the maximum possible results from any given treatment it is essential to consider the completion process as a series of interrelated and interlocking steps. The effectiveness of any fracture treatment is completely dependent on the manner in which the well is perforated.

Perforating procedure has been revised to permit hole density to be reduced from four or more holes per foot to two per foot. Also, the procedure permits a drastic reduction in total footage perforated. Perforating and fracturing are bound together by this new concept of well completion: *Each casing perforation is a target for fracture.* The design of fracture treatments is based on this concept plus the established fact that *each perforation will take fluid at a definite maximum rate.* Pump rate, stages and volumes are selected to insure that each hole is fractured. A study of case histories reveals that wells completed with the techniques described herein have a longer flowing life and a slower decline than wells conventionally completed. This indicates that these methods provide more efficient reservoir drainage, more effective use of reservoir energy and greater ultimate recovery.

This article describes developments in three basic phases of well comple-

ACKNOWLEDGMENT

The original paper on this subject, entitled "Developments in Well Completion Techniques," was presented to the 32nd annual fall meeting of the Society of Petroleum Engineers, October 6-9, 1957. Due to recently developed techniques and outstanding field data, the paper has been completely rewritten.

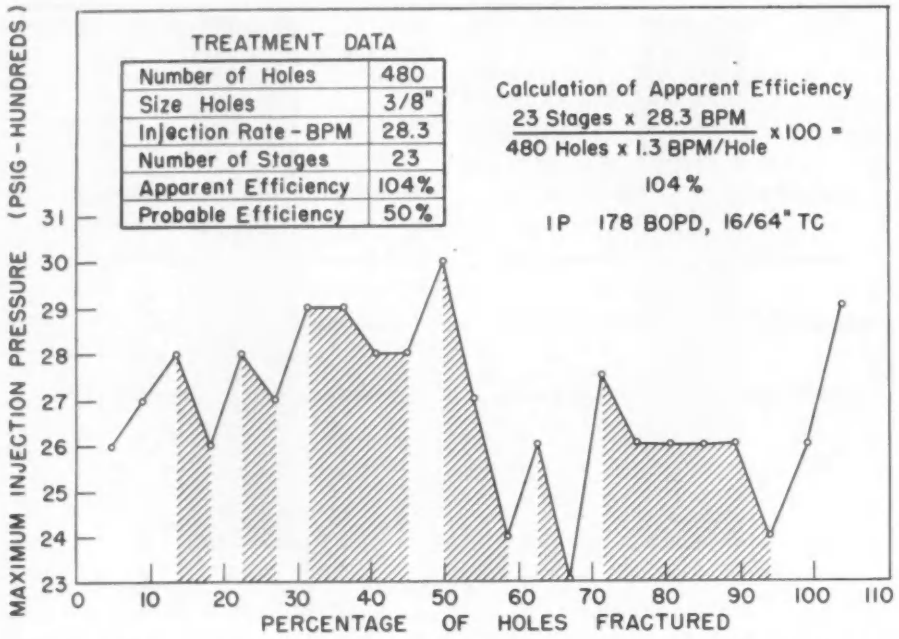

TREATMENT DATA
Number of Holes 480
Size Holes 3/8"
Injection Rate - BPM 28.3
Number of Stages 23
Apparent Efficiency 104%
Probable Efficiency 50%
Calculation of Apparent Efficiency
23 Stages x 28.3 BPM / 480 Holes x 1.3 BPM/Hole x 100 = 104 %
IP 178 BOPD, 16/64" TC
MAXIMUM INJECTION PRESSURE (PSIG - HUNDREDS)
PERCENTAGE OF HOLES FRACTURED

FIGURE 2—This is a fracture analysis curve of a West Texas well. Effective fracturing is occurring only when pressure increases with each additional stage. The shaded area is indicative of communication.

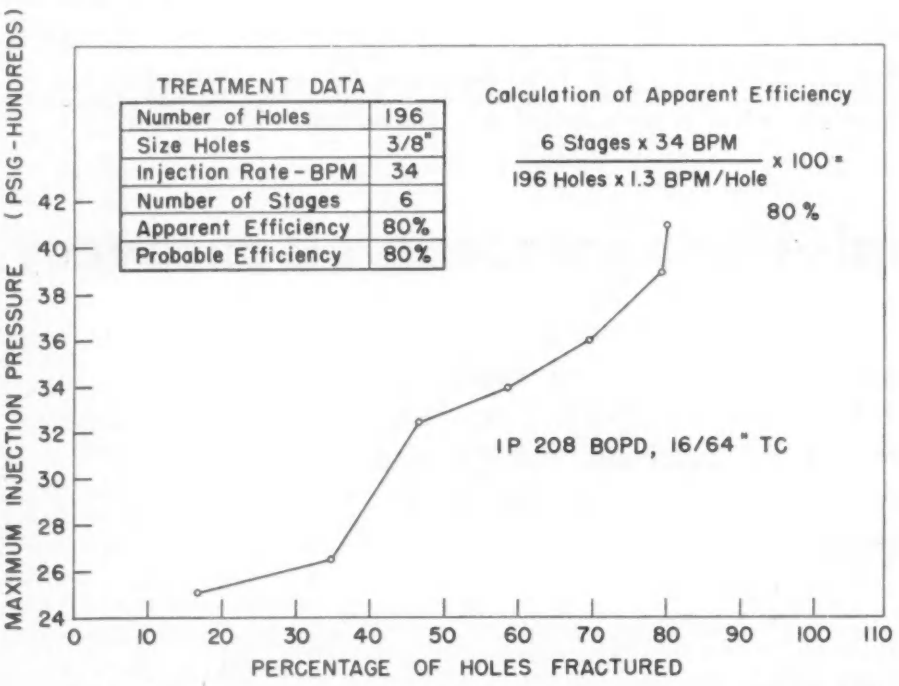

TREATMENT DATA
Number of Holes 196
Size Holes 3/8"
Injection Rate - BPM 34
Number of Stages 6
Apparent Efficiency 80%
Probable Efficiency 80%
Calculation of Apparent Efficiency
6 Stages x 34 BPM / 196 Holes x 1.3 BPM/Hole x 100 = 80 %
IP 208 BOPD, 16/64" TC
MAXIMUM INJECTION PRESSURE (PSIG - HUNDREDS)
PERCENTAGE OF HOLES FRACTURED

FIGURE 3—This is another fracture analysis curve of a West Texas well. Note the increasing pressure build-up with each additional stage. Communication is not evident, as in Figure 2.

tion: perforating procedure, fracturing procedure and the evaluation of the entire completion procedure. The completions covered in this paper concern wells which required fracturing or acidizing to induce or stimulate production.

PERFORATING

Since the practice of running casing through the pay zone has become common, it has become general practice to simulate open hole conditions by perforating four or more holes per foot. One ⅜-inch hole will pass approximately 78 barrels of oil per hour. For this reason it is not necessary to have a large number of holes to produce reasonable or even huge quantities of oil, water and gas. The true purpose of perforating is to produce fluid from each perforation and to provide a means of placing injected fluid at specific points on the formation. In other words each perforation should provide an isolated direct pipe line from casing to formation.

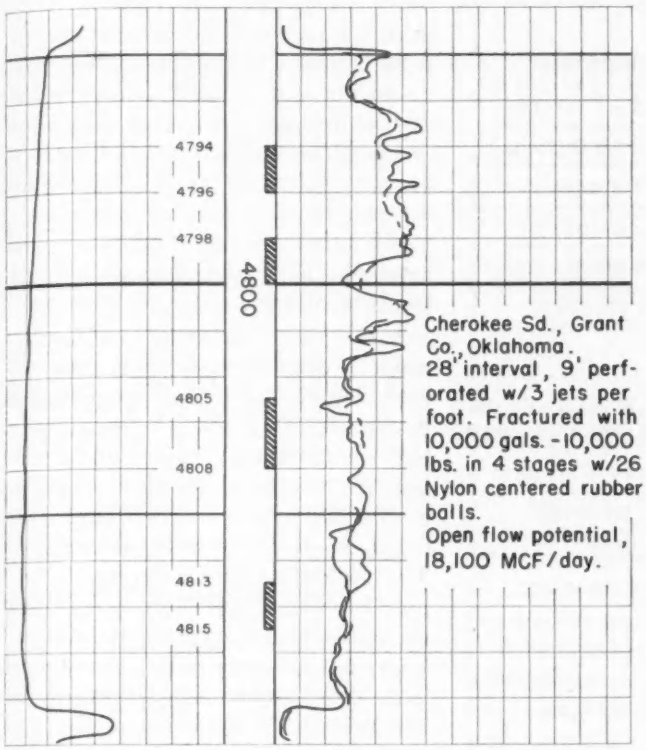
Perforating four or more shots per foot is detrimental to the well. Such practice results in almost complete destruction of the cement sheath which the operator went to great expense to place between the casing and the formation. When the cement bond is shattered, communication is a certainty. In this article, communication is defined as the movement of injected fluid in any direction other than in its intended path. Figure 1 illustrates the desired action of fluid and the action of fluid when communication occurs.

Analysis of treating pressures on many wells reveals that shot densities of less than four shots per foot treat at higher pressure. This is one indication that communication is being controlled or eliminated. Figures 2 and 3 show the pressure behavior of two wells on the same lease. Well No. 18 was perforated with four holes per foot. Well No. 22 was perforated with two holes per foot. Elimination of communication will assure complete vertical coverage of each perforated interval; all parts of a pay zone, regardless of permeability, will be exposed to treatment.

Close attention should be given to the placement of perforations within a pay zone. It is good operating practice to avoid shooting unnecessary holes. Impermeable zones and upper and lower extremities of the pay zones should be avoided when perforating.

Another recent innovation particularly adaptable to large intervals, is the practice of perforating selected small sections spread over the entire pay. The basic theory behind this practice is that a few well placed fractures will drain a reservoir. Blank spaces between perforated sections will act as buffers to completely eliminate communication. An actual example of this type completion procedure is shown in Figure 4. The high open flow potential is attributed to the success of the perforating procedure in eliminating communication and confining the treating fluid to the productive areas within the pay.

The size and position of the holes around the circumference of the casing are considered to be quite important. Holes larger than ⅜-inch in diameter are desired. The larger holes permit greater fluid velocity and maxi-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4813
4815
Cherokee Sd., Grant Co., Oklahoma. 28' interval, 9' perforated w/3 jets per foot. Fractured with 10,000 gals. -10,000 lbs. in 4 stages w/26 Nylon centered rubber balls.
Open flow potential, 18,100 MCF/day.

FIGURE 4—(Above) This perforating procedure is recommended for wells with extensive producing zones. The figure illustrates the microlog from a gas well in Grant County, Oklahoma. The indicated results are superior compared to offset wells.

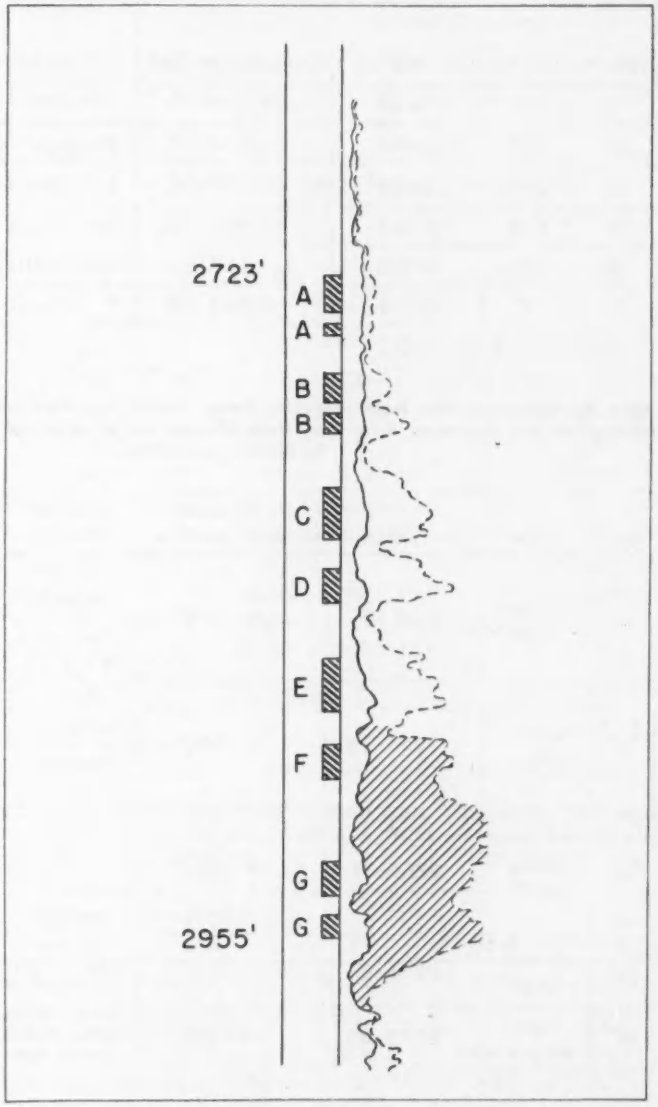

FIGURE 5—(Right) A tracer log of Well 18 is shown. The well showed considerable pressure variation (Figure 2) indicating a large amount of communication. The shaded area in this figure confirms this communication. The solid line is the base log. The dotted line is the tracer. The tracer should approach the base line above and below each zone. As indicated, it is impossible to determine the number of zones actually fractured.

mum radial movement before lateral velocity decreases to the point where sand will fall out. It is important to obtain radial coverage through any given zone. Shots should be positioned in the gun to allow holes to be aimed in all directions around the well bore. This perforation arrangement permits adequate treatment in all directions from the well bore.

The preceding recommended perforating procedure eliminates communication, enables the operator to place the treating fluid at the desired point and reduces perforating costs by as much as 50 percent per well.

FRACTURING METHODS

Hydraulic fracturing is so successful as a means of stimulating production that it is difficult to persuade operators to change from old to new practices. Despite this reluctance to change, the size of treatments has gradually increased as has the tendency toward higher injection rates. Most treatments were selected on the basis of past experience or rule of thumb type thinking. There was actually no concrete basis for engineering a fracture treatment.

Marion Stekoll[1] conducted experiments which indicated that crude oil carrying 2 pounds of sand per gallon could be pumped through a ⅜-inch hole at 1.3 barrels per minute under reasonable (300 pound) differential pressure. This data has been confirmed by injection rate tests in oil wells. Table 2 shows the results of these tests using various fluids. In each case sufficient horsepower was available to far exceed the maximum rate obtained.

Fracture treatments began to be designed using this theory plus a natural conclusion that each casing perforation is a target for fracture fluid. The explanation of why wells fractured at high injection rates responded better than those at low rates lies in the fact that fluid was entering more perforations. This in turn indicated greater vertical coverage of the perforated interval and greater radial coverage of the surrounding reservoir. It was concluded that maximum effectiveness was obtained when fracture fluid entered the formation through each and every hole.

To determine the pumping rate necessary to assure complete coverage of a perforated interval multiply the number of casing perforations times the applicable injection rate per hole. In wells having large pay sections (or in cases of multi-zone wells) required pumping rates often exceed the capacity of existing equipment. For these cases various methods were derived. Straddle packers, bridge plugs, cement and plastic plugs, etc., were used to

TABLE 1—Completion Cost vs. Potential. Almost all wells provided with engineered completions are still flowing after a two year period.

Well	Initial Potential		Completion Cost	Treatment Procedure
	BOPD	Choke Size		
12	152	14/64	34,078.00	Straddle Packers (7 settings)
14	67	10/64	20,808.00	Straddle Packers (6 settings)
15	290	16/64	18,754.00	Ball Sealers (17 stages)
18	178	16/64	13,469.00	Ball Sealers (23 stages)
19	120	12/64	11,113.00	Ball Sealers (13 stages)
21	110	16/64	9,414.00	Ball Sealers (9 stages)

TABLE 2—Observed Per Hole Injection Rates. These injection rate tests confirmed the validity of the Injection Rate Per Hole Theory as a practical basis for engineered hydraulic fracturing.

Well	Zone	Perforations	Perforation Number and Size	Injected Fluid	Observed Injection rate
"A"	Skinner Sand	4102-6	16 – 3/8"	38 API Lease Oil	1.5 BPM
				Refined Frac Oil	1.3 BPM
"B"	Crews Sand	2255-72	7 – 3/8"	42 API Lease Oil	1.7 BPM
				Refined Frac Oil	1.3 BPM
"C"	Crews Sand	2264-71	14 – 3/8"	42 API Lease Oil	1.7 BPM
				Gelled Lease Oil	2.0 BPM
"D"	Crews Sand	2273-80	7 – 5/8"	42 API Lease Oil With F/L Additive	5.2 BPM
"E"	First Wilcox	6779-85	24 – 3/8"	Kerosine & Acid w/Silicate Swelling Control Agent	1.1 BPM

TABLE 3—Case Histories, Maramec Field, Pawnee County, Oklahoma. In all cases shown, wells completed in accordance with this article are flowing in excess of the production which must be pumped from conventionally treated wells.

Well	Perforated Interval	No. Holes	Natural Prod.	Treatment x 1000	IP Bbls/Hour	90 Days BOPD	120 Days BOPD
K 1	3220-42	176	4 BOPD	10 gals. - 20 lbs. / 1 stage - 11 BPM	F - 40	P - 30	P - 26
2	3223-45	184	2 "	10 gals. - 20 lbs. / 1 stage - 11 BPM	F - 36	P - 38	P - 21
3	3230-72	330	8 "	10 gals. - 20 lbs. / 1 stage - 11 BPM	F - 42	P - 46	P - 29
4	3218-40	176	6 "	10 gals. - 20 lbs. / 1 stage - 10 BPM	F - 30	P - 26	P - 16
6	3224-58	68	2 "	15 gals. - 30 lbs. / 6 stages - 14 BPM	F - 40	F - 288	F - 40
A 1	3225-60	280	4 "	10 gals. - 20 lbs. / 1 stage - 10 BPM	F - 40	P - 40	P - 18
2	3227-58	241	2 "	10 gals. - 20 BPM / 1 stage - 11 BPM	F - 20	P - 30	P - 15
3	3229-59	60	show	15 gals. - 30 lbs. / 5 stages - 14 BPM	F - 40	F - 240	F - 60
M 1	3230-62	252	show	10 gals. - 20 lbs. / 1 stage - 11 BPM	F - 30	P - 60	P - 28
2	3228-76	96	show	15 gals. - 30 lbs. / 7 stages - 14 BPM	F - 40	F - 720	F - 120
3	3224-70	92	show	15 gals. - 30 lbs. / 7 stages - 14 BPM	F - 42	F - 600	F - 100

isolate formations or parts of formations so that treatments could be confined to a specific area. These methods were costly and time consuming. To remedy this situation stage or multi-fracturing was devised. This method of fracturing utilized temporary solid or chemical material to block part of a zone while another part was being treated. Stage fracturing has proven to be more efficient and more economical than the previously used mechanical methods.

Early stage fracturing design consisted of deciding how many fractures were desired (each stage is equivalent to one additional fracture) and applying the treating volume in a like number of stages. Various quantities of blocking agents were dumped or injected into the well between stages. The validation of the injection rate per hole theory has enabled operators to calculate the proper number of stages on a sound mathematical basis. This development has increased the effectiveness of stage fracturing.

Table 1 illustrates the difference in the number of stages required before and after the advent of the method of calculating the number of stages required. Stage fracturing eliminates the necessity for excessively high injection rates. This results in reduced costs since less horsepower will be required to complete a particular treatment.

Success of stage fracturing depends on effectiveness of the blocking agent and on the condition of the cement bond between the casing and the formation. Two distinct types of blocking agents are in general use.

If the well is new and has been perforated in accordance with the principles previously mentioned, the cement bond is considered to be good. In these cases ball sealers are used to provide a mechanical seal for the casing perforations. The advantages of ball sealers over other agents are:

1. They can be counted in the hole during injection. The exact number to plug each hole can be injected into the well.
2. They provide a positive seal.
3. If properly sized they will not pump through perforations under reasonable temperatures and pressures.
4. They can be recovered and inspected (98 percent of balls injected have been recovered

where conditions have permitted their removal).

In old wells or wells perforated with four or more holes per foot, the cement bond is thought to be shattered. In these cases an attempt is made to plug at the face of the formation. Crushed moth balls have been highly successful in fulfilling this requirement. The quantity to be used is based on pounds per hole to be plugged. This varies from well to well but a minimum of 15 pounds per hole is necessary. Other blocking agents are in general use; however, only ball sealers and crushed moth balls were used on jobs discussed herein.

TREATMENT DESIGN

Design of a fracture treatment should not be attempted until the perforating plans are firm, since rate, stages, etc. are dependent upon the number and size of the perforated holes.

Volume. Selection of a specific fluid volume with which to treat a well is a matter of choice. To date there has been little data presented on optimum volume selection. Determination of treating volume is presently based on gallons per hole rather than gallons per foot. Sand volume is dependent on the sand-carrying quality of the treating fluid and the type section to be treated. Previous experience is a valuable aid in making these selections.

Pump rate. Using the injection rate per hole theory it is possible to calculate the most efficient and economical horsepower requirements for each treatment. The maximum pump rate required to fracture all holes is determined as follows:

Pump rate (bbls/min) = number of holes × injection rate per hole. The best pump rate is that which can be maintained at a predetermined maximum pressure. It is desirable to maintain a constant rate throughout the treatment. Variation of rate causes treating pressure to vary. This completely negates the value of pressure in fracture analysis. Any sharp reduction in rate will cause blocking agents to lose their seal and increase the possibility of sandout. Pumping rates (horsepower) can be reduced by dividing a treatment into additional stages. In cases where the required pumping rate is excessive or where well conditions limit the rate, it is necessary to apply stage or multi-fracturing techniques.

Stage selection. The number of stages required for a job can be determined from the following formula:

$$\text{No. Stages} = \frac{\text{Injection Rate Per Hole} \times \text{Number of Holes}}{\text{Pump Rate Selected}}$$

Blocking agent. As previously mentioned, ball sealers and crushed moth balls are used as sealing agents. With ball sealers, one ball per hole to be sealed is ample; with moth balls a minimum of 15 pounds per hole is required to seal. The total quantity of either agent used is determined by dividing pump rate by injection rate per hole. The effectiveness of a stage treatment is governed by the plugging qualities of the blocking agent. A pressure increase should occur after each stage. If none occurs it is good practice to increase the quantity of blocking agent after the next stage. Combination jobs are not uncommon. If pressure indications are not satisfactory with ball sealers, moth balls should be used to attempt a formation block.

COMPLETION EVALUATION

The ability to evaluate a treatment at the well site is an important technological tool for the engineer. A method of calculating fracture efficiency using pressure behavior and injection rate per hole has been developed. A standard is necessary to begin. This standard is called design efficiency and is calculated as follows:

$$\text{Design Efficiency} = \frac{\text{1st stage pump rate}}{\text{Number of perf} \times \text{inj rate per hole} + \text{2nd stage etc.}}$$

Design efficiency can be calculated

TABLE 4—Case Histories, Southeast Jennings Field, Creek County, Oklahoma. Average results from two open hole completions are compared with 18 cased wells. Results are evident.

Well	Completion Method	Natural Prod.	Treatment x 1000	IP	90 Days	120 Days
2	Open Hole (50')	8 BOPD 18 BWPD	15 gals. - 30 lbs. 1 stage - 7 BPM	P-35 BOPD 20 BWPD	27 BOPD 19 BWPD	17 BOPD 22 BWPD
18	Perforated Casing w/2 shots per foot	10 BOPD 10 BWPD	15 gals. - 30 lbs. 15 stages - 15BPM	Flow 40 BOPH 25 BWPH	Flow 120 BOPD 120 BWPD	Flow 100 BOPD 100 BWPD

TABLE 5—Completion Comparison of Offset Wells, Grant County, Oklahoma. Pertinent completion data concerning each well is shown. Note the excellent results obtained on well S-1 when compared to the remaining completions.

Well	Net Pay*	Perforated Interval	Number Of Perforations	Calculated % Porosity*	Fracture Treatment	Actual Fracture Efficiency	Open Flow Potential
P-1	23	4820-26	24	10.8 %	4500 Gal. In One Stage @ 4.9 BPM	8 %	5000MCF
M-1	5	4787-95	32	15.0 %	10,000 Gal. In Five Stages @ 3.5 BPM	16%	6600MCF
B-1	22	4792-4807	60	11.2%	10,000 Gal. In One Stage @ 23.2 BPM	9%	5100MCF
S-1	14	4787-89 4793-96 4799-4801	14	9.0%	16,000 Gal. In Four Stages @ 17 BPM	100%	15,100MCF

*Calculated From Electric Logs

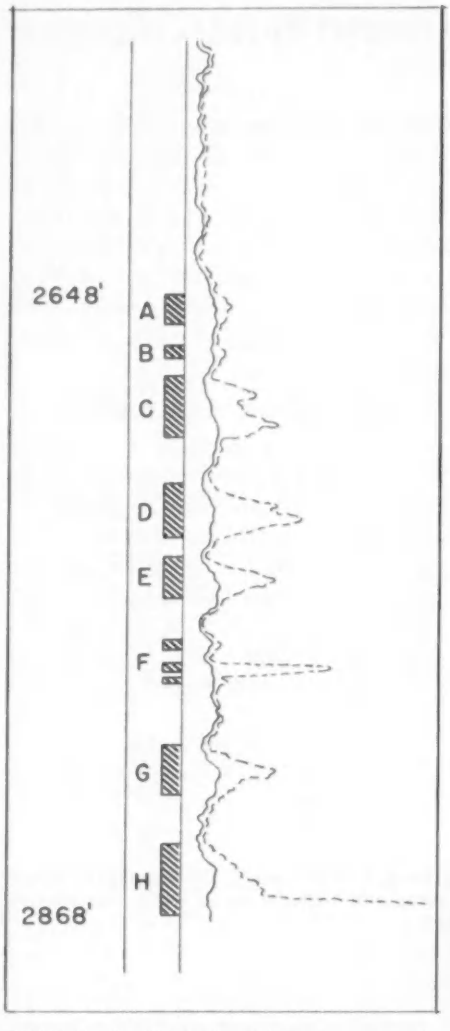

FIGURE 6—Well No. 21 had constantly rising pressure with no downward trend (Figure 3). The tracer log shown indicates no communication.

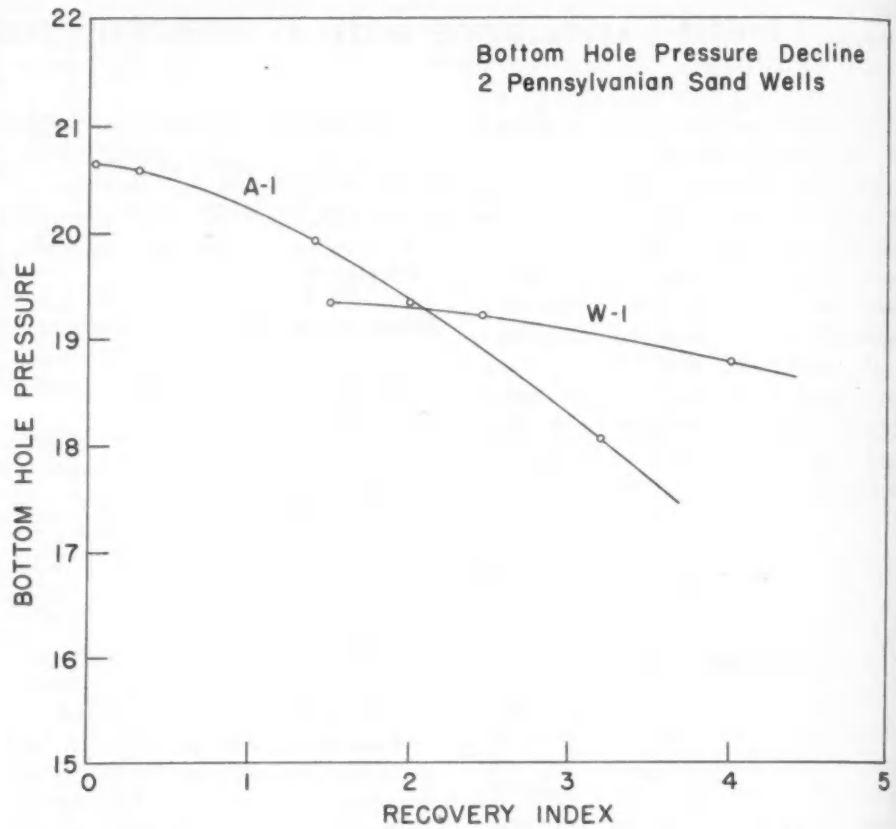

FIGURE 7—The decline of bottom hole pressure with recovery index for two wells completed in the Cherokee sand in northern Oklahoma. The term "recovery index" is defined as the ratio of cumulative oil production to barrels per acre in place. Well A-1 was treated with 5,000 gallons and 7,500 pounds sand in one stage at 4.5 barrels per minute. Well W-1 was originally treated with 6,000 gallons of oil with no sand. It was later necessary to retreat W-1 in order to produce the assigned allowable. The retreatment was 12,000 gallons—12,000 pounds sand in five stages at 12 barrels per minute. Comparison of the reservoir properties of the two wells reveals that well A-1 had 7,900 barrels per acre oil in place and a permeability of 543 md-ft. Well W-1 had only 4,350 barrels per acre in place and a permeability of 291 md-ft. It appears from the curves that well W-1 (despite being a poorer pay zone) has the lower rate of decline. W-1 apparently will produce a greater percentage of oil in place than Well A-1.

roughly prior to treatment and should be set to equal 100 percent.

Actual efficiency is derived by plotting treating pressure vs. percent of holes fractured. Figures 2 and 3 are fracture analysis curves. Shaded areas at the curves indicate increments of the treatment where no new fracturing was being done. Subtraction of the percent of holes fractured during the stages where no pressure increase occurred (shaded area) from the design efficiency is equal to actual efficiency. It is absolutely necessary that pump rates be kept as near constant as possible. While new calculations can be made rapidly, interpretation of pressure patterns becomes erratic under sharp and frequent rate changes. The greater the actual efficiency the more successful should be the treatment. Wells having high actual efficiency treatments would be poor risks for refracturing. On the other hand wells having low actual efficiency should be considered for reconditioning and refracturing.

Treatment Failure. At times, a treatment carried out with high actual efficiency (assuming reasonable volumes have been used) fails to respond as well as had been expected. In this case it is assumed that the well has been adequately treated. Further treatment would be uneconomical.

When a well treated under low actual efficiency conditions fails to react as expected, remedial operations can be applied. There are three causes of fracture failure (low actual efficiency):

- Improper design of treatment.
- Mechanical failure during the job.
- Communication.

The first two conditions are easily diagnosed and remedied. The third, communication, is considered to be the principal cause of treatment failure.

When communication occurs between holes within the pay zone (Figure 1, Panel B) only one fracture is created and only a part of the reservoir is affected. This occurrence usually results in fairly good potentials but rather sharp production decline. When communication between zones occurs, (Figure 1, Panel C) the entire formation is untouched. The results here could be disastrous: premature and unwarranted abandonment. Communication can exist in all wells, new or old. Recognition of its occurrence during a treatment is another important tool in the hands of the engineer.

As previously mentioned, each stage of a multi-stage treatment should be accomplished at a higher pressure. When pressure remains constant or declines, communication is indicated. The shaded area in Figure 2 is in-

dicative of communication. Figures 5 & 6 are tracer logs run immediately after treatment of the wells shown in Figures 2 and 3. Note the difference in the tracer logs. Each log compares favorably with its respective fracture analysis curve. Figure 5 confirms the communication suggested in Figure 2. Sufficient additional tracer work was done on other wells to confirm these conclusions.

RESULTS

In order to be of value to the industry, a tool or technique must do a job better or cheaper. Statistics gathered on wells completed in the manner advocated indicate that both requirements are being met.

Table 1 is a cost comparison of treating methods on several wells on the same lease in West Texas. Initial production figures are comparable. After two years of production most wells treated in the manner advocated are flowing, while the "straddle packer" wells are all pumping. A typical pay section consisted of 7 to 9 separate zones spread over an interval of 200′ (Figures 2 & 3 are typical of the spacing and size of the pay sections). The zones in wells 12 and 14 were individually treated using straddle packers as the separating mechanism. Wells 15 and 18 were treated using rule of thumb methods of selecting rate and number of stages. Wells 19 and 21 were treated in accordance with the previously described methods.

Twelve additional wells were drilled and completed similarly to Wells 19 and 21. At an average saving of approximately $15,000 per well for fourteen wells, the total amount saved on one lease was $310,000. Savings of this magnitude are possible in special cases; however, studies indicate savings up to 25 percent of completion costs can be obtained on most completions.

The outstanding results of these engineered treatments are that flowing life is lengthened and the rate of decline is reduced. Table 3 illustrates this point. The wells listed are from several Layton sand leases in eastern Oklahoma. In every case wells completed in accordance with this article have flowing production in excess of that which must be pumped from wells conventionally treated.

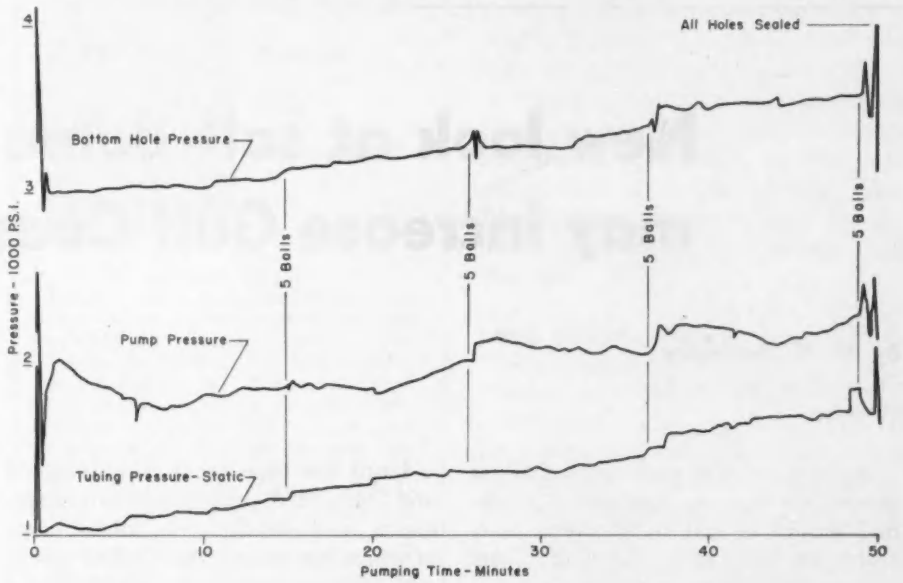

FIGURE 8—This pressure analysis curve of Well S-1, Grant County, Oklahoma, indicates that pressure increased after each stage. Every hole was fractured. Note that all three curves are in close agreement. Despite having relatively poor quality pay (Table 5), Well S-1 had an open flow potential of 15,100 Mcf.

A comparison of open hole completions with engineered well completions is shown in Table 4. The figures shown are averages for two open hole completions and 18 cased wells from several leases in the same field in eastern Oklahoma. The results shown are highly gratifying.

Figure 7 shows the decline of bottom hole pressure with recovery index for two wells completed in the Cherokee sand in northern Oklahoma. The curves indicate that W-1 despite being a poorer pay zone has a lower rate of decline and more important it appears now that W-1 will produce a higher percentage of the oil in place than will Well A-1. The improved flowing characteristics of W-1 are attributed to stage fracturing.

Figure 4 is a tracing of the micro log from a gas well in Grant County, Oklahoma. The spacing of perforated sections was designed to create a controlled system of fractures. The well was perforated with three holes per foot where fractures were desired. Permeability was then created where needed, to effectively drain the sand body. The spacing of intervals allowed sufficient separation between fractures to eliminate communication. The well was treated with 10,000 gallons and 10,000 pounds in four stages at 5.5 barrels per minute. The open flow potential was 18,100 Mcf/day. This is 2½ to 5 times greater than two offset wells conventionally perforated and treated.

Further evidence of the desirability of creating a controlled system of fracture is provided by a comparison of four gas wells which offset each other in Grant County, Oklahoma. Table 5 shows the pertinent completion data for each of the wells.

Well S-1, despite having the poorest quality pay, had an open flow potential of 15,700 Mcf. This is approximately double the best previous potential. Well S-1 was perforated in a like manner as the well shown in Figure 4. The treatment was designed to fracture every hole.

Investigation of the pressure behavior (Figure 8) indicates that pressure increased after each stage. The actual efficiency therefore was 100 percent: every hole had been fractured. The three curves shown in Figure 8 represent actual bottom hole pressure (a bomb was suspended in the tubing on bottom during the treatment), the static tubing pressure and the treating pressure (annula space). All three curves are in relatively close agreement. At the end of the treatment five balls were dropped to check the design of the treatment. The

Continued on Page 197

PART 1: Problems of detailed correlation

New look at salt dome geology may increase Gulf Coast reserves

By V. N. Sovinsky
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ALTHOUGH UNORTHODOX drilling procedures may be required, a modified theory of salt movement may reactivate interest in the Gulf Coast salt dome province which, in turn, may result in the drilling of fewer dry holes on salt structures and in discovery of new major crude oil reserves.

The present geological concept of the southern part of the Gulf Coast salt dome basin is derived largely from geophysical and comparatively scarce paleontological data. Prevalent geological opinion considers this area as sloping toward the middle of the Gulf of Mexico and eastward toward the old estuary of the Mississippi River. It is assumed that dips increase with each successive deeper horizon of the sedimentary column. Theoretically, it is estimated that a thickness of 30,000 to 35,000 feet of Miocene and younger sediments might be expected in the negative areas.

In the past, several attempts were made to differentiate Miocene sediments. Since outcrops are thin and subsurface study of the Miocene was not organized until recently, existing regional cross-sections usually show sediments younger than Oligocene as "undifferentiated."

As long as the search for oil was confined to Oligocene and older rocks, Miocene was drilled through and no data, except electric logs and some paleontological reports, were collected. Usually, different companies prepared some sort of regional Miocene maps. These were plotted on one or another random horizon without detailed electric log correlation. Some paleontological data were used as aids. Wells in the same field are correlated in most cases. However, a detailed correlation, even between adjacent fields, is lacking.

Until this basic work is undertaken and completed, problems of salt movements and stratigraphic distribution of sediments cannot be studied properly. Proper concept depends upon the study of regional geology. Until this is achieved, operators are dependent upon geophysical prospecting.

The value of geophysics cannot be denied, but each tool has its own range. While structures were abundant, no harm resulted by neglecting the geological tool. Since the percentage of dry holes is increasing, it is imperative that the actual geological picture of a given area be investigated. This basic knowledge must be obtained before Gulf Coast operators can determine the best place to look for undiscovered oil.

Problem of Miocene correlation. The present-day concept is that no *detailed* correlation between fields is possible. In the author's opinion, two ideas are responsible for this misconception: that Miocene sediments are of the deltaic type with sharp facies changes occurring at short distances and that regional dip exists not only in negative areas but also on salt structures.

Figure 1 shows an electric log from two widely separated wells. For clarification, the logs are cut in places where missing sections are indicated. It is apparent that correlation is good. In many intervals, even small individual peaks can be matched peak for peak. It should be noted that the distance between these wells is 45 miles. If correlation is possible at such a long distance, then the idea of widespread sharp facies changes is wrong.

It is known that Miocene sediments are marine in the Gulf Coast area. To satisfy the fact that good correlation is possible over long distances, the assumption must be made that contemporary shore lines were considerably inland from present day shore lines. Also, it must be assumed that the sea often was shallow (less than 75-80 feet). Miocene sediments brought to sea by contemporary rivers were dropped near the estuaries and spread out by currents and wave action into blanket deposits. Furthermore, it must be assumed that accumulation of the sediments was slow and that no quick burial was possible.

Although no proper figure can be estimated, an accumulation of one foot of sediments per 300 years can be assumed for clarification. The intervals on the logs (Figure 1), marked by letters between selected shale breaks, will represent the total approximate sedimentary accumulation during 30,000-50,000 years. This is such a long period of time that the "leveling-off" process (by wave action and currents) will practically "even" all minor local changes of deposition.

A change from blanket sand to blanket shale will depend more on the source of sediments and depth of water than on anything else. Facies changes will occur both downdip and laterally. However, it should always be remembered that facies changes of marine sediments are dependent mostly on water depth and not so much on distance. If present-day Gulf Coast conditions can be considered a sample of the past, note that the submerged shelf along the coast line extends for such a distance that the 100-foot depth is 50 miles from shore. Therefore, the gradient is 2 feet per mile. Under these conditions, facies changes are very gradual when time is taken into account.

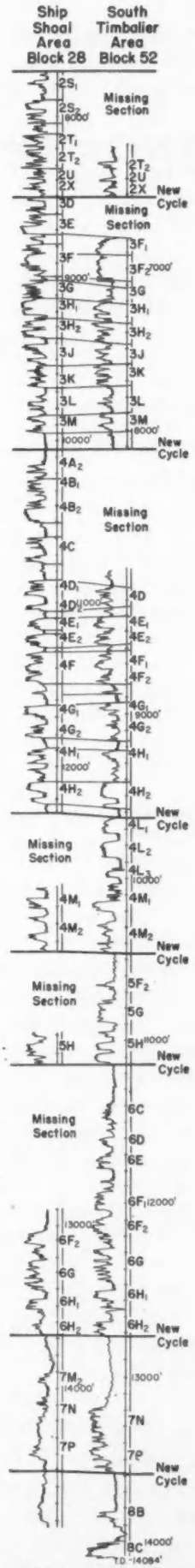
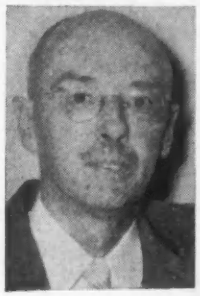


FIGURE 1—Electric logs from two wells in Louisiana Gulf Coast area. This correlation over such a distance indicates that the concept of widespread, sharp facies change is incorrect.



About the Author

V. N. Sovinsky was educated in Europe and at Columbia University. He recently retired as staff geologist in Gulf Oil Corporation's Houston Production division. He is a member of the American Association of Petroleum Geologists, Houston Geological Society and American Geographical Society. He was employed for 11 years by the American Geographical Society (1924-1935) and 23 years by Gulf Oil Corporation (1935-1958). During his Gulf Oil service, he worked on the geology of England, Denmark, France, Sicily, Italy, Greece, Middle East, Tunisia, the Caribbean area, Central America and South America.

Regional dip. The existence of regional dip cannot be denied. This idea is factual when applied strictly to negative areas (the area between salt structures). However, as soon as this concept is applied to positive areas of movement (to salt structures), it becomes dangerous. In this case, it is preconceived that each salt structure has the same rate of growth and the same period of growth. Known facts repudiate this.

For clarification, assume that at some point 200 miles offshore, the mother salt started to warp during Cretaceous time. Also, assume that the rate of growth of the structure was slow but still a little faster than the rate of deposition. A similar structure 100 miles closer to shore, stopped growing during late Oligocene time. Therefore, some 30,000 feet of sediments will have been deposited above this second dome. In this case, only the dip in the Cretaceous can be measured, and it is a northern dip. Regional dip obviously does not exist in positive areas of the salt dome province. When logs are correlated from inland structures to offshore areas, there is a tendency to move the correlating horizon downward because of regional dip. Not only is this unjustified, but it also might lead to gross error.

Paleontological data should be used with caution. There is no doubt that these data help the correlation. At the same time, it should be realized that lithologic correlation might cross biostratigraphic horizons (see GSA & AAPG Bulletin Vol. 59, pp. 447 and Vol. 40, pp. 2003). Unfortunately, it is common practice for some Gulf Coast geologists to consider certain microfossils (depending on the individual test) as a time horizon. Also, Electric log correlation may be unconsciously forced to conform with this idea.

Long range detailed correlation. The author decided to approach correlation with one preconceived idea: correlation always exists. If there is no apparent correlation, something is wrong and should be explained by indicating missing intervals.

The Long Range Correlation method was used throughout. Since practically no literature regarding this method exists, it is important that its general principles be explained.

Logs are plotted on sections in geographical order. Correlation starts from one end and proceeds forward until the loop is completed. Correlation never should be forced. Initially, only intervals that are unquestionably correlatable should be so marked. Additional details then are added as the picture becomes clearer. Correlation should be detailed. That is, every possible horizon from bottom to top should be marked; otherwise, confusion will result in miscorrelation. Skipping one or two logs is helpful when ambiguous correlation is evident.

A proper completion of the loop is not enough to be sure that the correlation is good. Actually, each well should be tied in with at least four other wells. In other words, each section line should be crossed by other lines, preferably at right angles. As long as work proceeds, constant small changes will be required on previously completed lines. The work is time-consuming and actually never-ending. However, the degree of accuracy attained soon becomes apparent. As soon as a small change on one log will require a change on more and more logs, the correlation will approach a rigidity that is surprising. In many parts of the world, that is precisely why it is generally accepted that correlation of logs between wells spaced from 10 to 20 miles apart is possible without too great an error.

The author's modified theory of salt movement will be presented in Part 2 in the November issue of WORLD OIL.

For Your PRODUCTION File

PART 4

Gas reservoir material balance can be helpful

Gas reserves, expected ultimate recovery, rate of production with time and effects of water encroachment can be attained by this method

By Frank W. Cole,
Assistant Professor of Petroleum Engineering
University of Oklahoma, Norman

A MATERIAL balance on a closed gas reservoir, i.e., no water influx, can be developed as follows:

SCF gas originally = SCF gas produced + SCF gas remaining

$$G(1/v_o) = V_g + G(1/v) \quad (1)$$

Where:

SCF = Standard cubic feet.
G = Reservoir gas space, barrels.
v_o = Gas conversion factor at original reservoir temperature and pressure, barrels/SCF.
v = Gas conversion factor at any later pressure and temperature, barrels/SCF.
V_g = Cumulative gas produced, SCF.

Equation 1 can be rearranged to solve for G, the size of the original gas reserve in barrels, as follows:

$$G\left(\frac{1}{v_o} - \frac{1}{v}\right) = V_g \quad (2)$$

$$G\frac{1}{v}\left(\frac{v}{v_o} - 1\right) = V_g \quad (3)$$

$$G = \frac{V_g v}{\left(\frac{v}{v_o} - 1\right)} \quad (4)$$

The gas conversion factor, v, is identical to the gas conversion factor used in oil reservoir material balance calculations. It is derived as follows: From the perfect gas laws:

$$\frac{P_1 V_1}{Z_1 T_1} = \frac{P_s V_s}{Z_s T_s} \quad (5)$$

where the subscript 1 refers to conditions at a specific time, and the subscript s refers to standard conditions.

By definition, v is equal to the volume in barrels, at reservoir temperature and pressure, occupied by one standard cubic foot of gas. Therefore, if V_s is equal to one, then the V_1 shown in Equation 5 is equal to v, after conversion to barrel units. The calculation of v is accomplished by use of the following equation:

$$v = \frac{P_s V_s Z_1 T_1}{P_1 Z_s T_s\, 5.62} \quad (6)$$

Since the quantities at standard conditions are known, Equation 6 can be simplified as follows:

$$v = \frac{(14.7)(1.0)(Z_1)(T_1)}{(P_1)(1.0)(520)(5.62)} \quad (7)$$

$$= 0.00504\,\frac{Z_1 T_1}{P_1} \quad (8)$$

The size of a gas reservoir can be calculated directly from Equation 4. However, as in all material balance calculations, the accuracy of this method is directly dependent upon the data used in the equation. In general, accuracy increases as cumulative gas production increases.

The amount of gas in place originally, in standard cubic feet, can be determined by the following equation:

$$\text{Gas Reserve, SCF} = G\left(\frac{1}{v_o}\right) \quad (9)$$

Thus, a method is available for estimating both the physical size of the reservoir and the amount of gas in place originally without the use of geologic data.

Gas reservoirs may be subjected to a water drive in the same manner as oil reservoirs. A material balance equation also can be developed to consider water influx into the reservoir. The basis for development of the equation will be the same as that used in development of the material balance equation with no water influx:

SCF gas originally = SCF gas produced + SCF gas remaining (10)

$$\text{SCF gas remaining} = \frac{G - (W - w)}{v} \quad (11)$$

It can be seen that gas produced is a result of gas expansion plus net water influx. Substitution of symbols and combining Equations 10 and 11 yields:

$$V_g = G\frac{1}{v_o} - G\,\frac{1}{v} + \left(\frac{W - w}{v}\right) \quad (12)$$

where:

W = Gross water influx into the reservoir, barrels.
w = Water production, barrels.
Other symbols—As shown previously.

Equation 12 contains two unknowns, G and W. Therefore, when a gas reservoir is influenced by a water drive, the material balance equation alone cannot be used to calculate gas reserves. Where good geologic data are available, the magnitude of water influx can be calculated from Equation 12 by rearranging to solve for W:

$$\frac{(W - w)}{v} = V_g - G\frac{1}{v}\left(\frac{v}{v_o} - 1\right) \quad (13)$$

$$\frac{W}{v} = V_g + \frac{w}{v} - G\frac{1}{v}\left(\frac{v}{v_o} - 1\right) \quad (14)$$

$$W = V_g\, v + w - G\left(\frac{v}{v_o} - 1\right) \quad (15)$$

Equation 15 can be useful in determining the additional recovery obtainable as a result of water drive. Also, it can be used to determine the rate of change of the gas-water contact for planning completion and recompletion practices, water disposal problems and other operating problems.

Here's one major producer's method of . . .

Organizing equipment standardization

Pan American Petroleum Corporation finds substantial savings in this effective company-wide program

By J. Zaba, Chief Equipment Engineering Supervisor,
Henry Schaefer, Equipment Engineering Supervisor,
Pan American Petroleum Corporation, Tulsa

PAN AMERICAN Petroleum Corporation has established an effective equipment standardization program in producing operations. The initial consideration of the program was selecting phases of operation in which standardization provided the greatest advantages. It was decided that the standardization effort should proceed along three lines:

1. Standardization of facilities. This includes tank batteries and treating facilities layouts, well pumping installations, compressor and plant installations and electrical transmission facilities.

2. Standardization of arrangement of equipment. This concerned methods of piping separators, treaters and other equipment, arrangement of valves and fittings in christmas trees and arrangement of electrical equipment on pumping wells.

3. Standardization of certain items of equipment, methods of design, use of equipment and materials as acceptable for use. Equipment standardization should involve selection of equipment based either on engineering specifications or on selection of certain types and makes of acceptable equipment.

The program was designed to comply with existing applicable codes and with regulations of state and federal government's regulatory bodies. The existing standards of the American Petroleum Institute, the American Society of Mechanical Engineers, the American Standards Association, the American Society of Testing Materials and others were to be used.

Mechanics of the program. To put the program into operation a Standardization committee was appointed with the superintendent of materials as the chairman. Personnel of the equipment and mechanical units of the Engineering section, the Purchasing department, and Safety section were included. Preliminary steps included discussions with Legal and Accounting department personnel. The mechanical engineers in the division offices were members of the committee and formed a liaison with the divisions in standardization matters.

Proposals for standardization originated with the general office Standardization committee and were based on ideas of this group or on suggestions of the divisions. Proposals, when worked out in detail, were sent to the divisions for their comments. The ideas, opinions and suggestions were coordinated in each division before meetings of the Standardization committee so that mechanical engineers from the division offices represented the thinking of the division managements. The committee discussed the proposals and made recommendations. When approved by management they became company standards.

Two problems of importance during development of the program were alternate standards and reconciling differences of opinions.

During development of the standardization program, Pan American was operating from Canada to the Gulf of Mexico and from Utah to Alabama. In such a situation, many operating conditions are encountered. Standards satisfactory for one operating area were not satisfactory for another. This situation called for alternate standards. In arranging for these alternates, judgment had to be exercised in distinguishing between actual need and personal opinions. Otherwise, the purpose of standardization could be defeated.

Standardization of facilities. Work on the program began with development of facilities and construction standards because they were urgently needed, and because this phase of standardization appeared to be the least difficult. As experience was gained, other more difficult phases of the program were dealt with. The development of tank battery standards is an illustration.

Advantages of having company-wide tank battery standards are:

- Standards, as finally developed, would represent the composite experience and thinking of many individuals.
- Compliance with all company safety policies and neatly appearing installations are assured.
- Changes in tank battery arrangement, with changes in supervisory personnel, are eliminated.
- Since standards include bills of materials, there is a considerable saving in time of field clerical forces in preparing and handling requisitions through channels.
- Since tank batteries are built by contract work, drawings are needed to accompany bids. Availability of

This article is based on a paper presented to the 13th Annual American Society of Mechanical Engineers Petroleum-Mechanical Engineering Conference in Denver, Colo., Sept. 21-25, 1958.

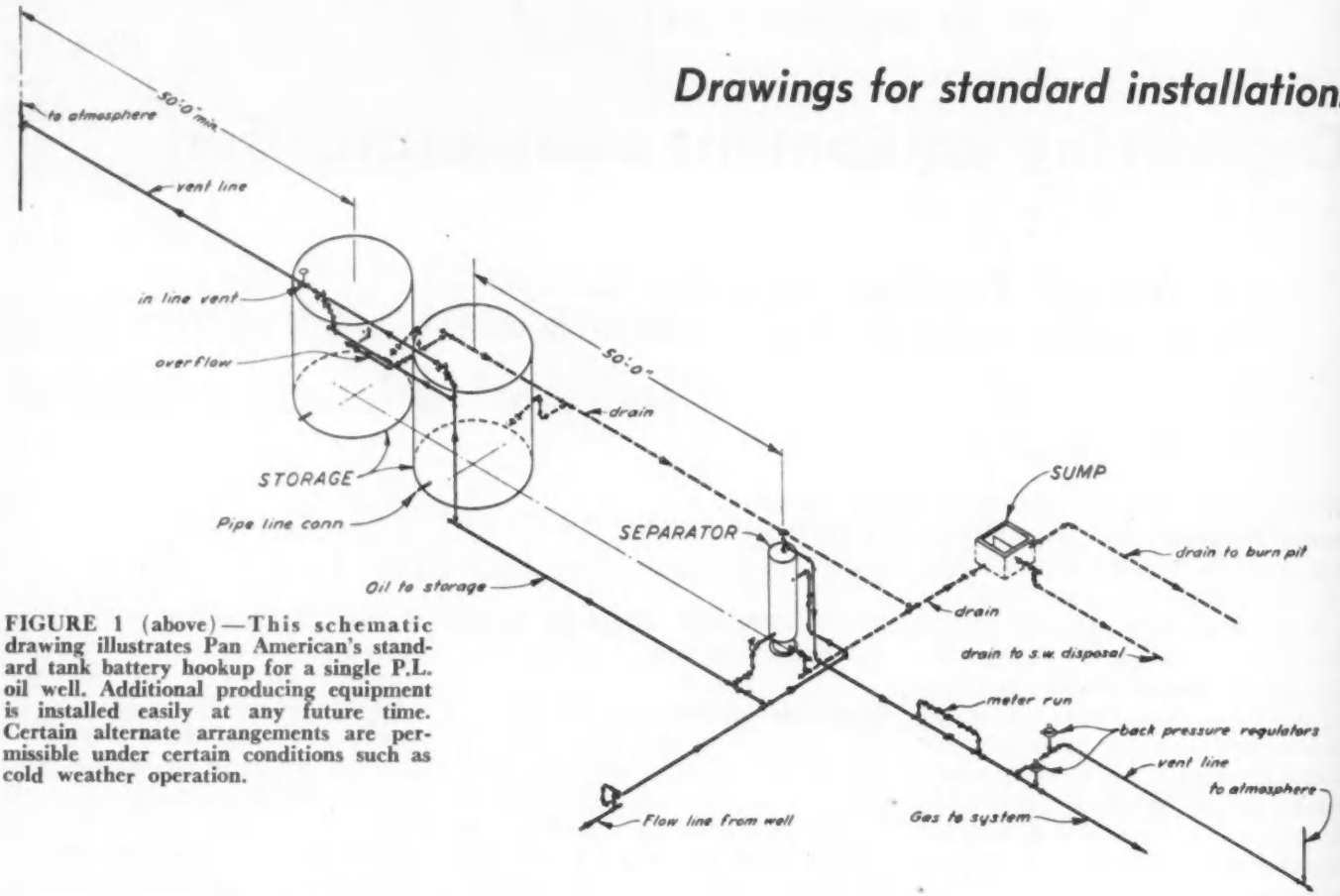
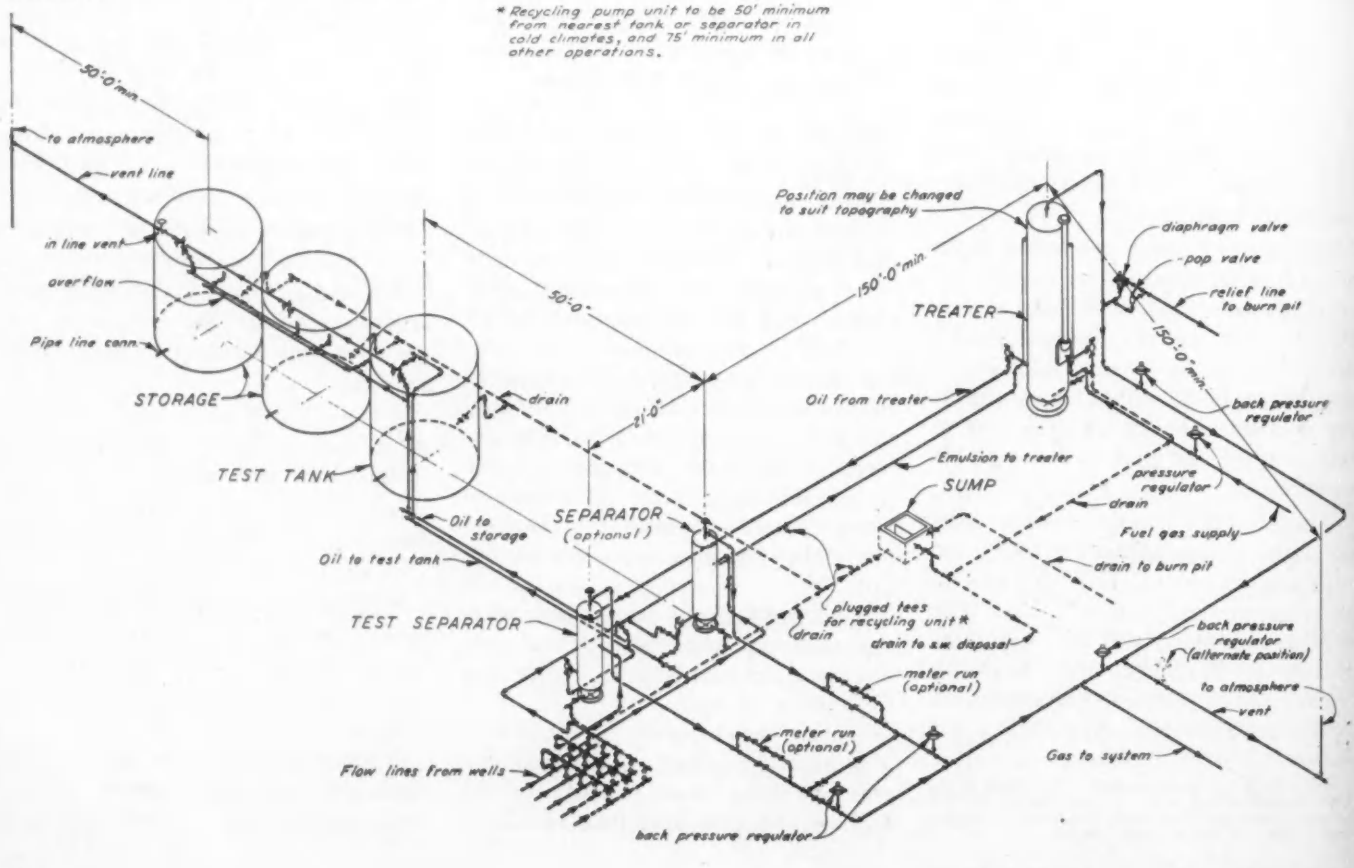


FIGURE 1 (above)—This schematic drawing illustrates Pan American's standard tank battery hookup for a single P.L. oil well. Additional producing equipment is installed easily at any future time. Certain alternate arrangements are permissible under certain conditions such as cold weather operation.

FIGURE 2 (below)—Treating facilities, test separator, additional tankage and manifolding have been added to the installation shown in Figure 1. Due to the standardized design, these additions were made without disturbing the initial installation.



save time for engineering personnel . . .

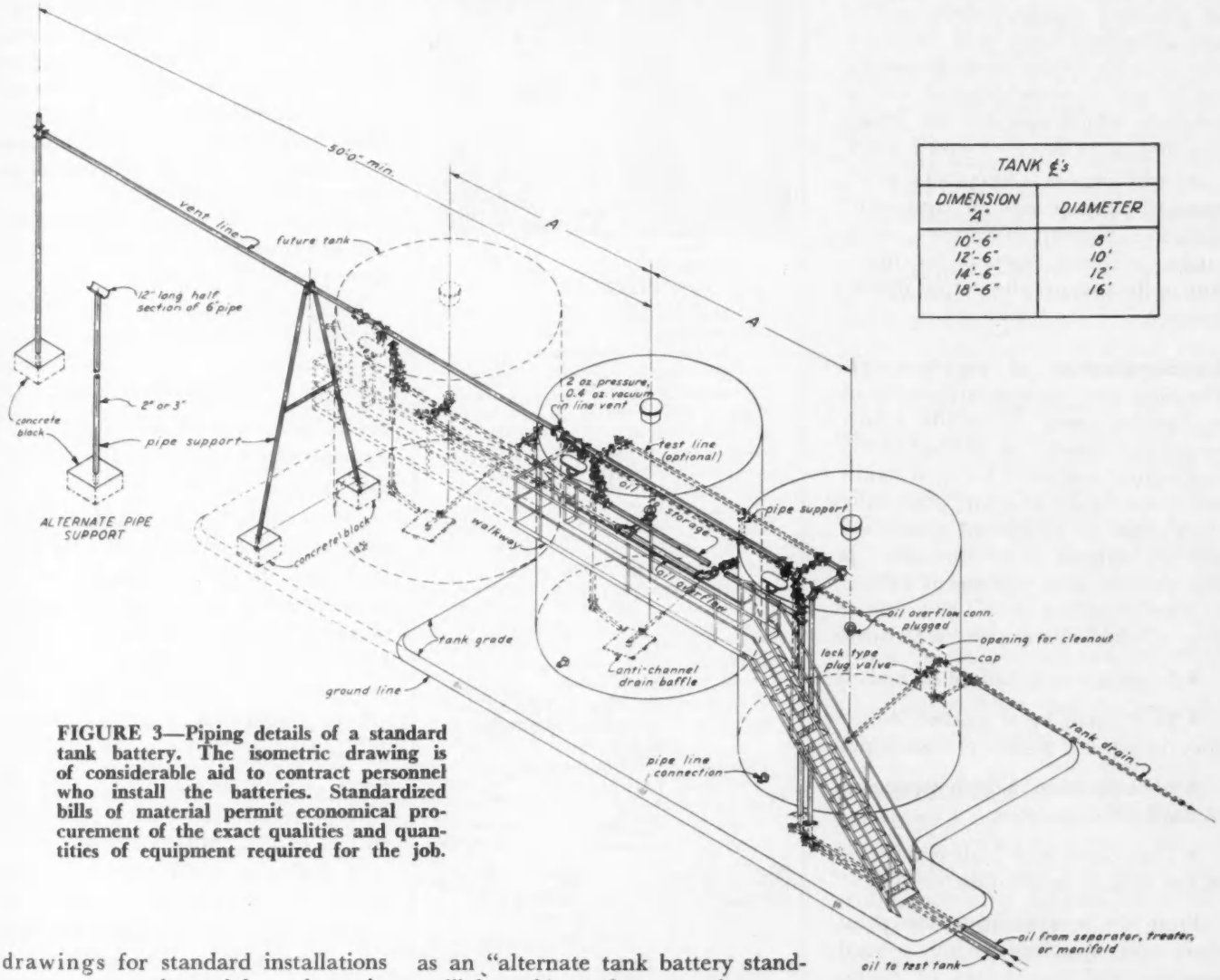


FIGURE 3—Piping details of a standard tank battery. The isometric drawing is of considerable aid to contract personnel who install the batteries. Standardized bills of material permit economical procurement of the exact qualities and quantities of equipment required for the job.

drawings for standard installations represents a substantial savings in time for engineering personnel.

To permit adding to tank batteries without disturbing the original arrangement, a pattern of "evolution" was followed. The first hook-up is a battery serving one well which makes pipe line oil. Second was the addition of another well using manifolding and a test separator. Treating facilities then were provided. Addition of other wells, which may require an increase in tankage is handled by adding necessary equipment without disturbing the original arrangement.

It was necessary to provide certain alternates, such as arrangements for cold weather operations in the Rocky Mountains and Canada. This included lowering of tank overflow lines to obtain sufficient head for the flow of viscous oil, housing tank battery elements and changes in manifolding arrangement. These were combined as an "alternate tank battery standard" for cold weather operations.

Tank battery standards specify the size, type and make of tanks; separators and treaters to be used; define the relative positions of different elements of the battery; and show connections, manifolds and auxiliary equipment.

Drawings, some of them isometric, and bills of materials are part of the standards. Construction drawings of adequate scale are available. Figures 1 to 3 show some typical installations.

In addition to tank batteries, construction standards cover sales gas meter settings, electrical distribution systems, fencing for tank batteries and wells and low temperature separation units.

Standardization of equipment arrangement. An example of standardization of arrangement of equipment was the establishing of standards for christmas trees. A tree usually is purchased as a unit from the manufacturer, with the make of connections specified by the purchaser. This procedure is followed because the unit can be better assembled and tested in the manufacturer's shop than in the field. The requisition for a christmas tree is lengthy since each component must be described in detail. To supplement the requisition, a drawing is furnished to the vendor showing the desired arrangement of the individual elements of the tree.

Prior to standardization, over 60 drawings of christmas trees were used by Pan American. In standardizing, three basic types (designated according to working pressure) were established. Each type was designed so alternates could be used to meet particular operating conditions. At present, 11 alternate christmas trees are

used. Figure 4 shows how one type of tree can be converted to alternates.

Drawings and bills of materials are provided for each tree. Vendors are provided necessary drawings. In requisitioning a tree, it is necessary only to refer to the drawing number and attach a mimeographed list of materials which specifies the make, sizes and types of valves and fittings.

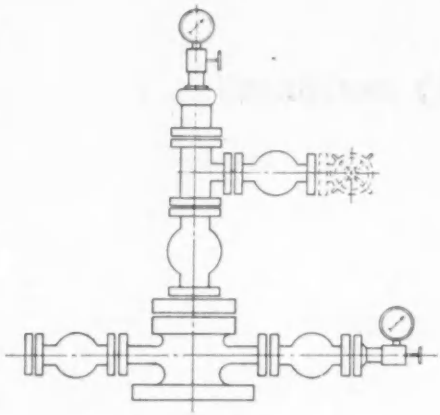
In addition to christmas trees, standard arrangement of equipment includes blowout preventers, work trucks, wellhead hookup for injection wells and installation of instruments.

Standardization of equipment. The first step in standardization of equipment was to decide which equipment should be included. A compromise was made between standardization rigidly affecting practically every item of equipment purchased and an extreme of no standards. It was decided that equipment subject to standardization should have one or more of the following characteristics:

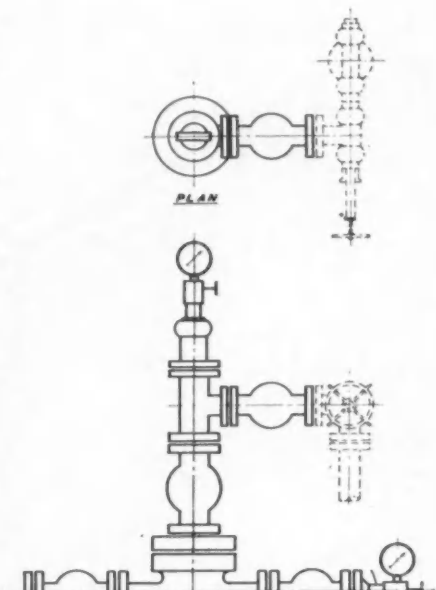
- Available in a variety of makes.
- That there be a marked difference in various makes of like items.
- That there be a high frequency of use by the company.
- That there be a high initial cost of the item or installation, or both.

From the engineering viewpoint there are two approaches toward selection and purchases of equipment. One approach is to define certain specifications which the equipment must fulfill to be acceptable. For instance, in the purchase of a pump, the volume to be handled, the working pressure to be used, the materials of different components and a number of mechanical details can be defined. This is considered a standardization according to engineering specifications.

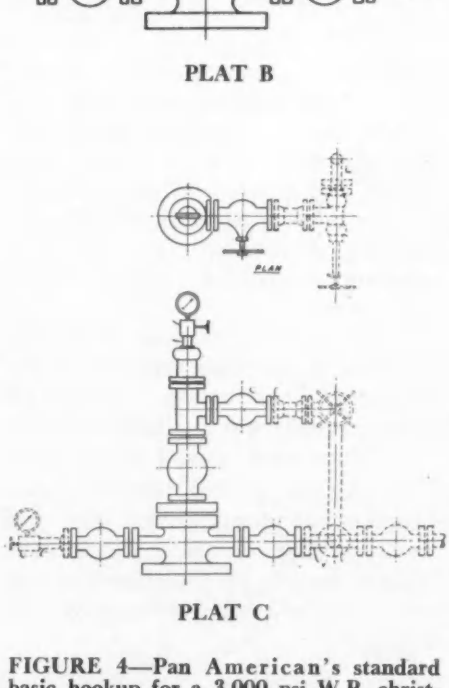
Selection and requisitioning the many items of equipment used in producing operation through specifications is not practical because of the volume and diversity of the items purchased. A second approach is to base the choice of an analysis of information obtained on different makes of certain items of equipment. This second approach is illustrated by work on standardization of pumping units.



PLAT A



PLAT B



PLAT C

FIGURE 4—Pan American's standard basic hookup for a 3,000 psi W.P. christmas tree is illustrated in Plat A. Plats B and C show how alternate hookups can be derived from the basic design. Double master and wing valves are optional on any hookup.

Questionnaires were sent to all pumping unit manufacturers in the country. These queries requested engineering data on structurals, gears, materials used, types of bearings used, type of counterbalance and many other engineering details. At the same time, a second set of questionnaires was sent to all company field offices asking for experience with units from the point of view of performance, safety, ease of adjustment of counterbalance, type of service rendered by the manufacturer and availability of spare parts.

Information obtained from these two questionnaires was combined, and relative ratings of the units were worked out. An arbitrary number of points was assigned to the different elements of the unit in such a manner that a total of 100 would represent an ideal unit. For example, if ideal structurals of a unit require 15 points, analysis of the data obtained from the manufacturers indicated how many points should be assigned to the structurals of a particular make. A number of points was assigned to the availability of spare parts and to the type of service rendered by the manufacturer. The total of these points for each make represented the relative ratings of the units surveyed.

It then was decided that the first five units with top ratings would be placed on the list of standards and be acceptable for purchase. This provided field men an opportunity for selection and also gave the Purchasing department a choice in purchasing units. From the engineering point of view, it was immaterial which of the five makes of units would be purchased.

This item of equipment which caused the most difficulties as far as standardization was concerned was the subsurface sucker rod pump. This is understandable since there are available commercially several thousands of pumps, considering size, length, API type, make and arrangement of the elements etc. In checking, it was found that the company was using 961 types, makes and sizes of sucker rod pumps. Because field men (who are responsible for pumping the wells) should have the final say on selection of a pump to be used under

given well conditions, questionnaires were sent to all fields requesting the makes, types and sizes of pumps which would satisfy their requirements. Replies to the questionnaires were reviewed by the divisions and standardization committee. By eliminating duplications and requests not supported by facts indicating actual need, the list was reduced to a total of 192 pumps. Special lists were devised for each division, and the maintenance and enforcement of adherence to the list of standards was placed in the hands of the division offices.

The list of acceptable equipment is rather lengthy. To mention only a few items, it includes high pressure valves, pumping units and high pressure separators.

The third phase of work included certain standards on methods, such as standard procedures and sample calculations. Specifications also were prepared for the use of cement, paint and pipe coating and wrapping materials.

Testing program. One danger of standardization is the possibility of "rigidity." Just because a certain item of equipment is the best available at any given time does not necessarily mean that it will continue to be the best available. The oil equipment supply industry is highly competitive and dynamic. New items of equipment are being placed on the market continuously. To keep up with developments, field testing of such equipment is needed.

Frequently, a new item of equipment does not perform (under field conditions) according to expectations based on shop or laboratory tests. An unsuccessful field test may be quite expensive; not necessarily from the point of view of the initial cost of the equipment tested, but because of the cost of operations incidental to a test. If information on a test is confined to the test location, similar tests may be conducted in other locations with the total cost for a specific test rising to substantial proportions.

As an example, during a period of several years prior to 1948, a certain item of equipment was tested in 13 different locations and each time found unsatisfactory. Conversely, if the test is successful the equipment tested may represent a solution of an operating problem at many other operating locations. Information on such a test should be available to all locations of company operations.

Therefore, an equipment testing program paralleling the standardization program is a necessity. A simple form was prepared to request the test and report its results. At the conclusion of the test, the completed form is distributed to the operating offices of the company.

About the Authors

Zaba

Schaefer

J. Zaba was educated at the Vienna Institute of Technology, Vienna, Austria; the University of Krakow, Krakow, Poland; and the Mining Academy at Krakow. He arrived in the United States in 1924, entered the Graduate School of the University of Pittsburgh and received an M.S. degree in petroleum engineering in 1925. The companies Zaba worked for at first included Vacuum Oil Company and Rio Bravo Oil Company. After serving two years with an independent operator, he entered consulting practice in Houston in 1946. In 1948 he accepted his present position with the Pan American Petroleum Corporation (then Stanolind Oil and Gas Co.) as chief supervisor of equipment engineering in the company's general office at Tulsa.

Zaba is co-author of the "Practical Petroleum Engineers' Handbook" and more than 100 articles and technical papers on different phases of drilling and production practices.

Henry Schaefer studied mechanical engineering at University of Oklahoma, receiving a B.S. degree in 1932.

He worked several years for Oilwell Supply Co., and in 1935 joined Pan American Petroleum Corporation as an equipment engineer in their Tulsa general office. In 1940 he moved to Ellinwood, Kan. as petroleum engineer. From 1941 to 1944 he served as field engineer at Alvin, Texas, and Jennings, La. He returned to Tulsa in 1944 as research group supervisor and in 1952 was advanced to his present job.

Ten years' experience. Unfortunately, advantages of this type of standardization cannot be expressed easily in terms of money saved. It would require an unjustified amount of expense to determine, for the purposes of comparison, the cost of any given operation if standard equipment and methods were not used. However, there appears to be a consensus within the company that monetary savings resulting from standardization have been substantial. For instance, savings in engineering and clerical time alone brought about by existence of standard drawings and bills of material for installations amount to thousands of dollars each year.

In general, operation of the program is satisfactory. Probably the most difficult part of the program is maintenance of standards for subsurface sucker rod pumps.

A good criterion of the value of the equipment testing program is the interest displayed by different operating locations of the company in results of tests conducted at other locations. Using this interest as a criterion, it is felt that the program has been worthwhile.

Standardization and decentralization. It is felt that decentralization and standardization not only are compatible, but also that under decentralization the value of standardization is increasing.

Since authority of selection, requisitioning and purchase of equipment is being decentralized to division, district or field offices, the standards serve as a guide to assure that the most economical, efficient and safe equipment is being purchased. Effect of personal preferences and opinions is reduced. At the same time, considerable latitude of selection is left to the field men.

Decentralization does require changes in the mechanics of administering the standardization program. For instance, the approval and distribution of the results of tests now is handled by Pan American's division offices. However, final approval of the changes in the company-wide standards resulting from data obtained by field tests, is still handled in the general office.

ACKNOWLEDGMENT

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A new method

Optical analog computer simplifies gravity analysis

Operators can determine accurate gravity values from easily modified geologic models. Basic principles permit the instrument's adaptation to many potential field problems

By R. W. Baltosser, Senior Research Engineer
and S. W. Wilcox, Senior Research Engineer,
Seismograph Service Corporation, Tulsa

A NEW METHOD of interpreting gravity data is provided by the optical analog computer. The instrument is designed to enable geologists and geophysicists to analyze an easily modified geologic picture or model. The model is made by drawing to scale cross-sections or sketches which detail assumed or real earth-density distributions. When the model is placed in the instrument, readings obtained are equivalent to gravity values.

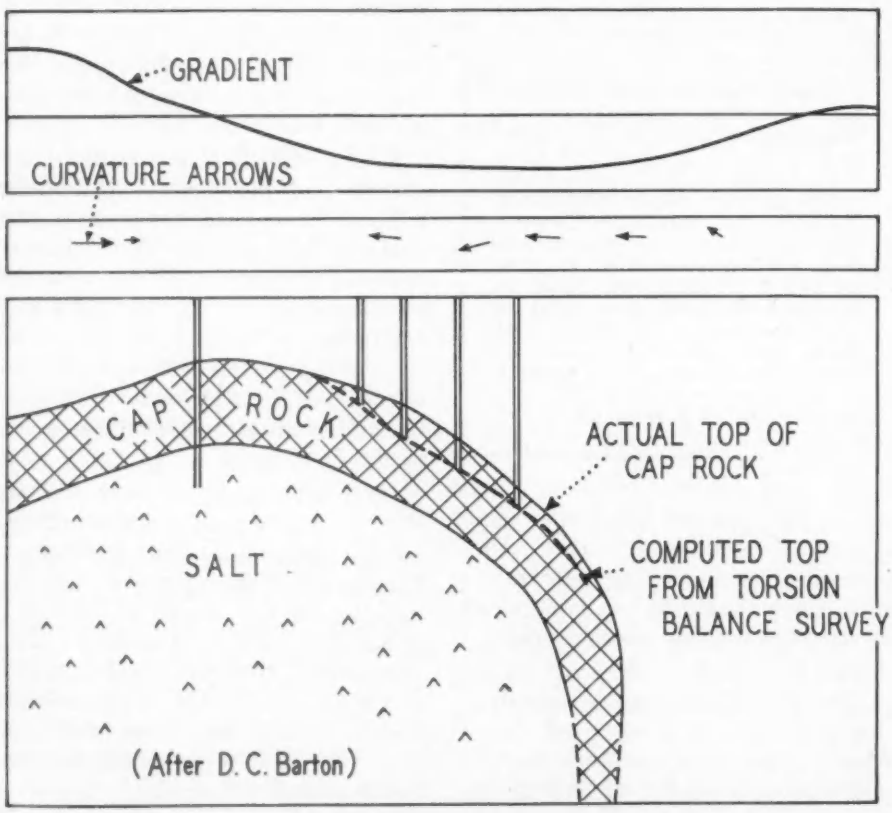


FIGURE 1—Simple models simulating buried salt domes have yielded helpful gravity pictures. Computations of such models are tedious. A classic example is the predicted outline of the Hoskins Mound salt dome.

Pioneers in torsion balance surveying recognized that ambiguity was inherent in that numerous equally plausible solutions existed when interpreting geologic significance of the data. In an effort to cope with the problem, the gravitational response of models was completed. Simple models simulating buried salt domes or ridges enclosed in sediments of known density contrasts yielded helpful gravity pictures. However, such computations were tedious. (Figure 1)

Introduction of the gravimeter did not change the ambiguity problem and model studies were continued. Unfortunately, mathematic complexity dictated use of simple model assumptions to decrease the work. One approach has been to reduce the model to a two-dimensional feature which can be calculated as an elongated body normal to the plane of the model. A complete discussion of the mathematics involved in applying this approximation is given by M. King Hubbert.[1] The mathematics can be expressed graphically. To simplify the amount of work associated with model studies, graticule charts were developed independently by numerous geophysicists. (Figure 2 and 3)

Primary application. The primary application of the optical analog computer is to investigate realistic geologic models (accurately scaled sketches or cross-sections) outlining the expected geologic configuration. Each significant geologic member of the cross-section is given an optical density or opacity proportional to the assumed specific gravity of the formation. Accordingly, this shaded specific gravity model layout is prepared to the required scale on transparent film. In operation, the film is placed in the instrument over an illuminated opening or window in contact with the optical graticule.

Each unit in the gravity graticule charts (regardless of physical size) contributes equal increments to the total gravity field. Optically, it is necessary only to construct a filter which will pass equal amounts of light for

ACKNOWLEDGMENT
This article is from "An Analog Computer," a paper which is scheduled to be published in the February, 1959, issue of *Geophysics*.

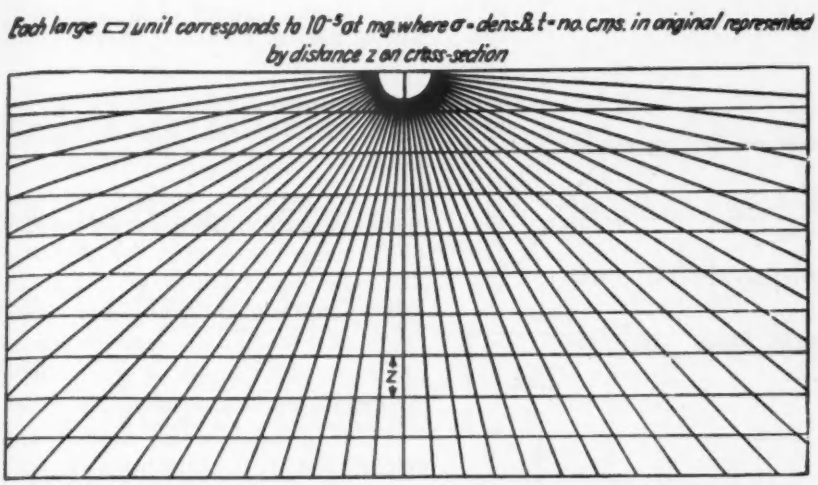


FIGURE 2—One type of graticule chart developed by D. C. Skeels is shown. When these charts are designed for two-dimensional model studies, the model is assumed to have infinite length normal to the plane of the graticule. The chart is laid out on a mathematically-developed geometric pattern. Each graticule is assigned unit area equal increments of the vertical force field. Thus, the approximate vertical force of irregularly-shaped, elongate, buried bodies may be determined by counting the number of graticule unit areas super-imposed on the model's cross-sectional outlines.

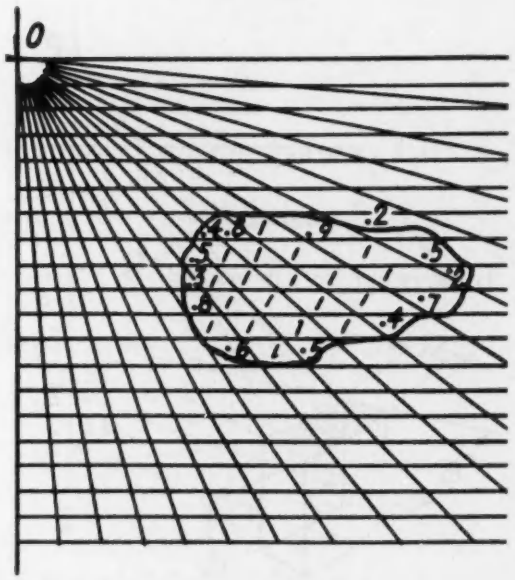


FIGURE 3—A model has been superimposed over a graticule (similar to that shown in Figure 2).

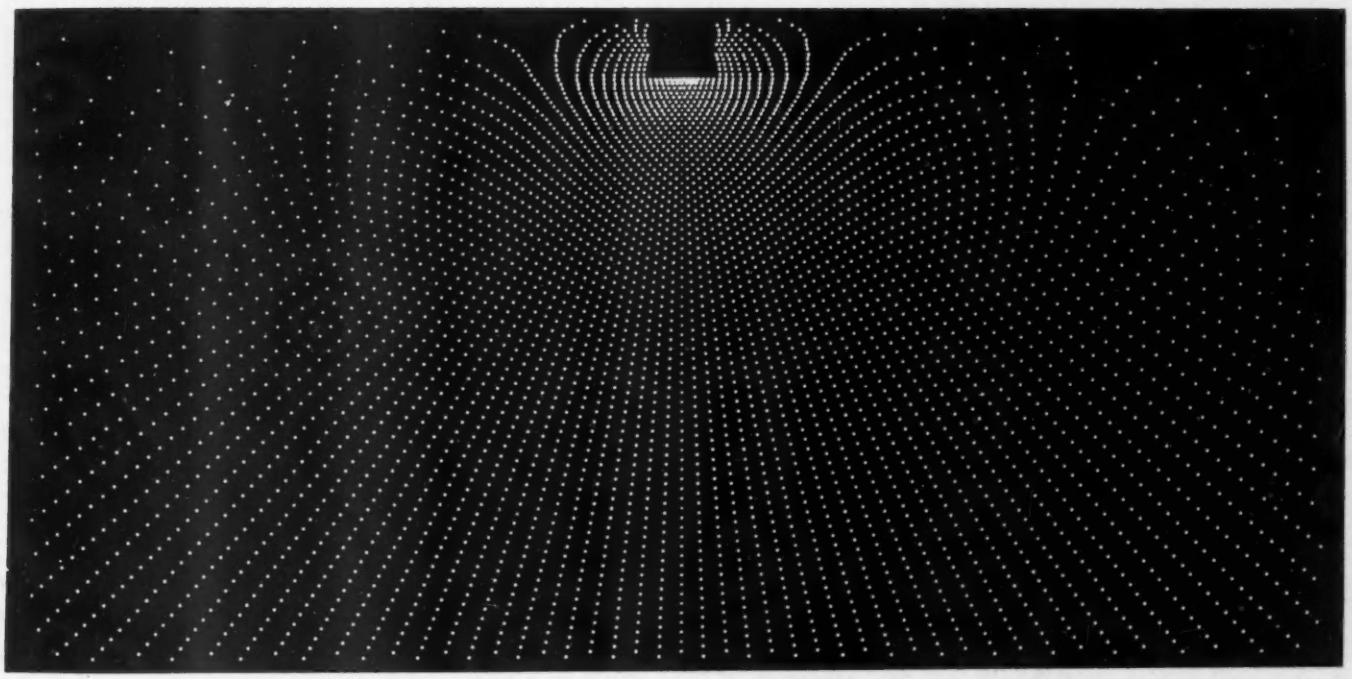


FIGURE 4—(Above) This optical graticule satisfies the mathematical requirements of the two-dimensional graticule theory. The graticule is used with a cross-section as shown in Figure 5.

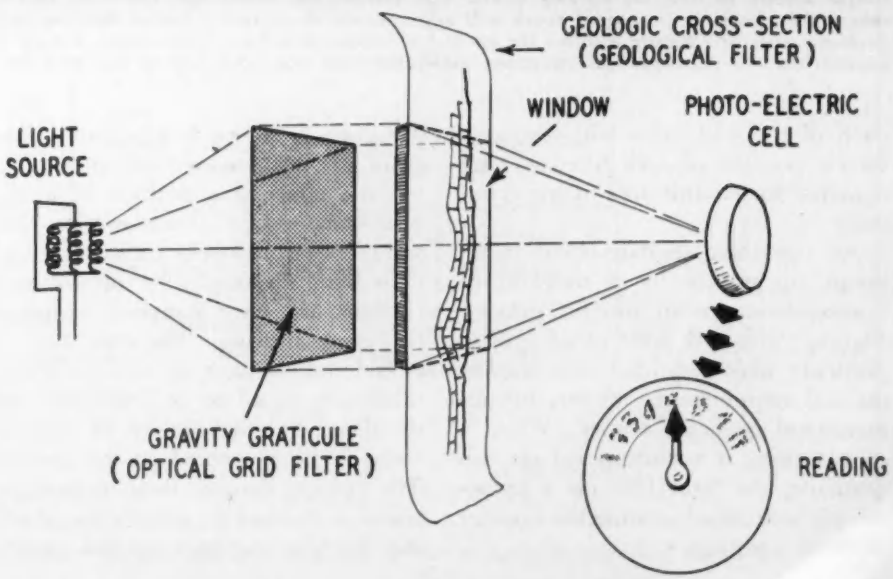
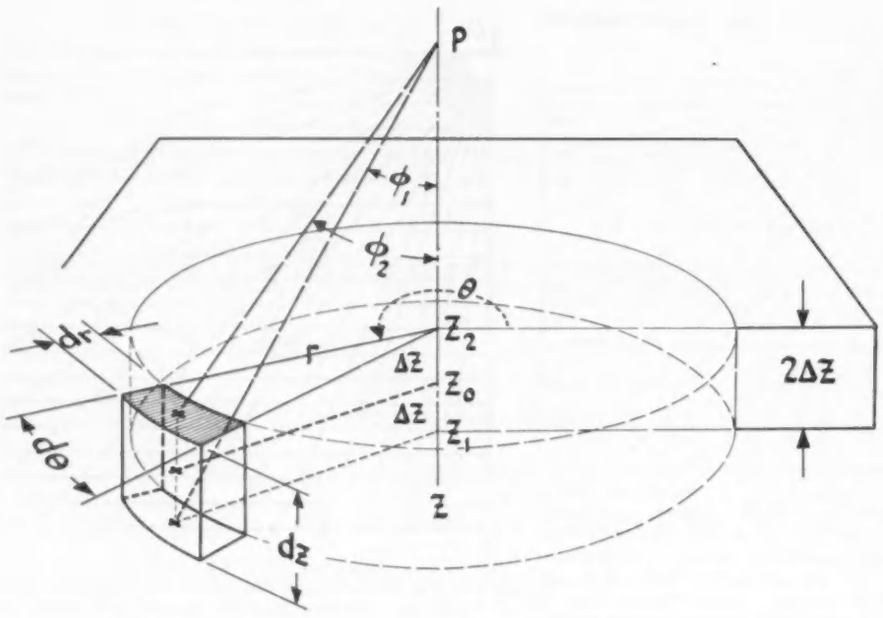


FIGURE 5—(Right) A schematic diagram of the analog computer is shown. Light passes through the optical graticule and the superimposed geologic cross-section, and is gathered by a suitable optical system onto the surface of a photo-electric cell. The electrical output of this cell is displayed by a dial set to read in milligals, or in some proportional part thereof. The geologic cross-section is moved across the optical graticule in proper geometric orientation to simulate the running of a gravity meter traverse. Instrument readings are recorded station by station for the geologic cross-section as the model is moved through the instrument.



(1) $dv = r\, d\theta\, dr\, dz$

(2) $dg_v = \rho \frac{dv}{R^2} \cos\phi$

(3) $dg_v = \int_{z_1}^{z_2} \frac{\rho r\, d\theta\, dr}{R^2} \cos\theta\, dz = \int_{z_1}^{z_2} \frac{\rho r\, d\theta\, dr}{(z^2+r^2)} \cdot \frac{z}{(z^2+r^2)^{1/2}} dz$

$= \frac{\rho r\, d\theta\, dr}{2} \int_{z_1}^{z_2} \frac{2z\, dz}{(z^2+r^2)^{3/2}} = \left[\frac{-2}{(z^2+r^2)^{1/2}}\right]_{z_1}^{z_2} \cdot \frac{\rho r\, d\theta\, dr}{2}$

(4) $= \rho\, d\theta\, dr \left[\frac{r}{(z_2^2+r^2)^{1/2}} - \frac{r}{(z_1^2+r^2)^{1/2}}\right] = \rho\, d\theta\, dr \left[\sin\phi_2 - \sin\phi_1\right]$

For this to be unique for all positions of z, Δz must remain constant and $\frac{r_{max.}}{z}$ also must remain constant.

FIGURES 6 and 7—The optical analog computer with the two-dimensional optical graticule is well suited for use with features such as faults, synclines, anticlines and other geologic features whose lengths are much greater than their cross-sections. In order to have an instrument which is of universal application, it is necessary that its use include three-dimensional bodies. This is readily achieved if, instead of vertical sections, horizontal sections are taken. In this case, the total effect of several layers is the sum of the individual layers. As the computer can readily obtain the effect of one layer, it is a simple matter to sum the various layers. The thinner the layers and the more layers taken, the closer the measured result will approximate the actual value of the assumed geologic structure. Figure 6 shows the geometric relationship for a single layer. Figure 7 summarizes the mathematical equations associated with the geometry of the problem.

each of the unit areas with the geometric position of each filter opening centered in the unit area of the graticule.

All openings simulate equal increments of gravity for a medium of homogeneous mean specific gravity. Figure 4 shows a print of an optical graticule which satisfies the mathematical requirements of the two-dimensional graticule theory. When a cross-section is superimposed on this graticule, the light falls on a photoelectric cell which counts the number of these openings.

Figure 5 shows a schematic diagram of the analog computer. To test the effect of a geologic concept, it is sketched as a cross-section (to scale) on transparent paper or film. This medium should be of uniform capacity and have a surface receptive to pencil drawing. The clear film is considered to have an optical transmissibility equal to or less than the simulated specific gravity of formations to be presented in the model. The optical density, then, is proportional to the specific gravity, i.e., shading the film increases optical density and represents an increase in the specific gravity.

An example. For example, if the geological cross-section to be studied is assumed to contain no formation of specific gravity less than 2.0 grams per centimeter, an optical transmissibility of 2.0 may be selected for the clear film. Geologic formations then are outlined to scale on the film. Since concern is only with specific gravity contrasts, only density contrasts need be considered in making up the model.

These formations are shaded with optical densities proportional to their assumed specific gravities. This shading is accomplished by using the instrument as a densitometer wherein small areas of the cross-section are compared against a standard.

Calibration of the instrument not only must recognize the range of degree of opaqueness of the models (from full light transmission to no light transmission) but also must recognize the scale of the model. Experience shows that the operator can control the average shading closer than 0.05 grams per cubic centimeter density contrast for any practical cross-section scale. Instrument calibration for three-dimensional studies is identical to that employed for two-dimensional studies. Although a special "scale calibration chart" is required, there are no changes in procedure. The same density contrast can be used as long as the instrument is adjusted to the proper scale of the horizontal section studied.

Accuracy. Taking into consideration the construction and calibration of the instrument and geologic model, accuracy is better than 5 percent. The repeatability of the computer, is in the order of 5 to 10 parts per thousand, depending upon the stability and drift characteristics of the particular instrument and the care exercised in operating the unit.

While the optical analog computer was designed specifically for gravity use, the basic principles permit its adaptation to all potential field problems. This would be accomplished by the construction of the appropriate graticules.

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[1] "Line Integral Method of Computing Gravity," M. King Hubbert, GEOPHYSICS, Vol. 12, No. 2, Page 215.

Exploration possibilities in southwestern Nebraska look good

Recent discoveries in the Lansing-Kansas City limestone and exploration possibilities of the Mississippian and Cambrian have increased drilling and leasing activity

By Richard F. Svoboda
Petroleum Consulting Geologist,
Lincoln, Nebr.

SOUTHWEST NEBRASKA drilling activity is increasing. The outlook is for a bright future because many objective potential oil producing horizons can be evaluated within 5,000 feet. The best chance for development of large petroleum reserves in the southwestern sector of the state lies in the Mississippian and Cambrian formations, which unconformably underlie the Pennsylvanian.

Truncation of Pre-Pennsylvanian beds and secondary weathering have created excellent reservoir conditions. Stratigraphic situations exist in Red Willow, Frontier, Hayes and Chase counties. The truncated wedge of Mississipian carbonates which overlie the Cambrian formations and underlie the Lower Pennsylvanian section are vulnerable to large petroleum accumulations.

New interest in the search for commercial petroleum was revived in southwestern Nebraska during 1956 with the first commercial discovery in the Barger field of Red Willow County, 10, miles northwest of McCook, Nebr. Previously, the nearest established oil production was located in the Warner field of Decatur County, Kans., over 25 miles to the south. Production in the Barger field is from the Lansing-Kansas City group limestone of Pennsylvania Age at an approximate depth of 3,860 feet below surface datum. During 1957, two additional oil discoveries were reported, the Poore field in Red Willow County and the Jones field in Dundy County. In February, 1958, a rank wildcat oil discovery was completed in Hitchcock County. Production from all counties is limited to the Lansing-Kansas City group limestones.

Production of oil from southwestern Nebraska thus far has not created flush

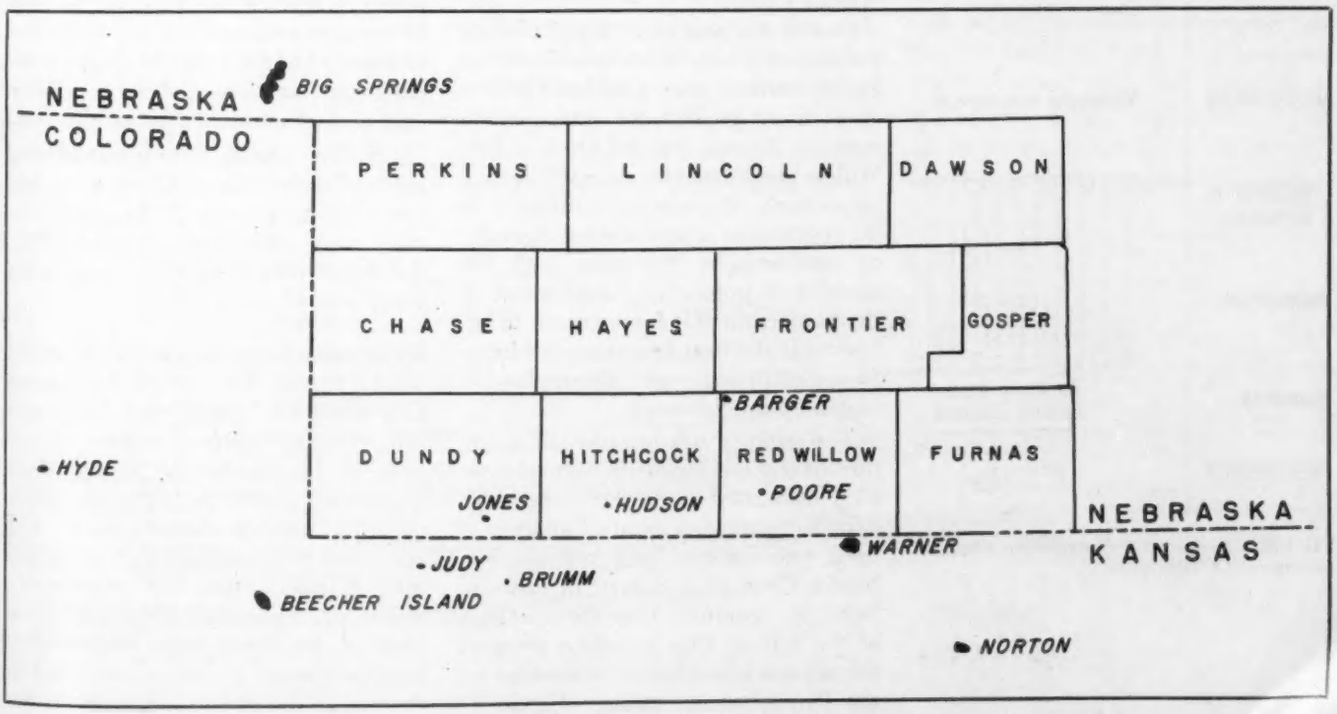

FIGURE 1—Recent discoveries in southwestern Nebraska and principal producing areas in adjoining states.

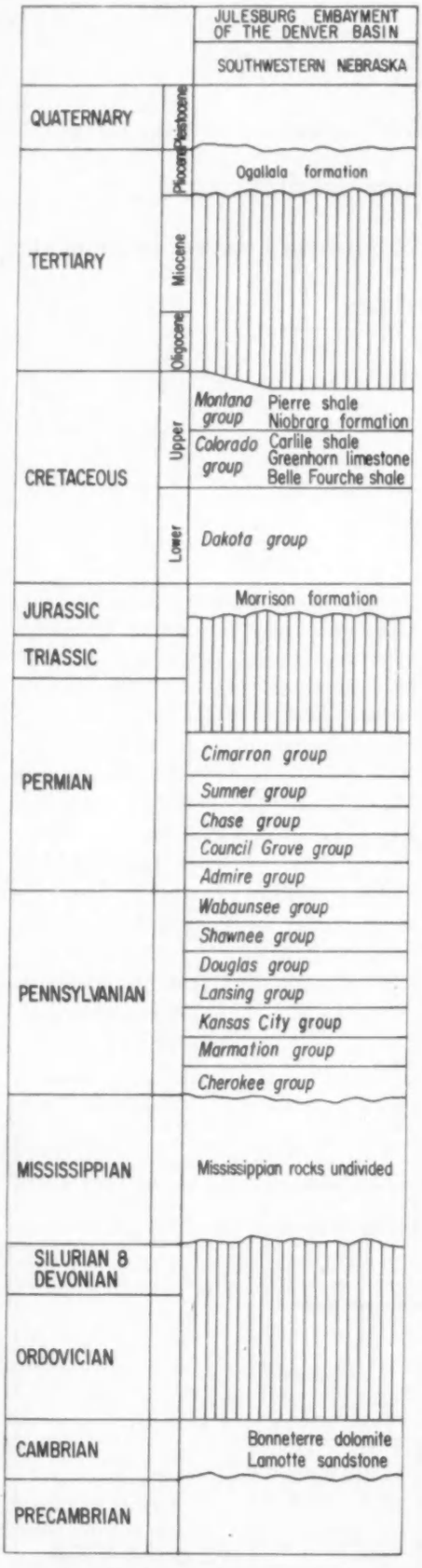

FIGURE 2—General Correlation chart of southwestern Nebraska.

petroleum reserves because of the nature of the limestone matrix within the Lansing-Kansas City formations. However, the subsurface information gained from recent exploratory activity provides needed data for a study of the potential oil accumulation in Cambrian and Mississippian strata lying unconformably beneath the Pennsylvanian sediments.

In June of 1956, a wildcat oil discovery, the Barger 1, drilled by M. P. Gilbert and Joe Rothmeier, located in Section 6, Township 4 North, Range 30 West, Red Willow County, renewed a lagging interest on the part of petroleum exploration geologists in an area with previous sporadic drilling activity.

Although the new field, named Barger, in itself is not a large and prolific field, it did establish oil production for the first time north of the Kansas border — an important milestone in the development of the petroleum potential in southwestern Nebraska. Petroleum exploration and development has expanded slowly along the Kansas west flank of the Cambridge Arch because of marginal production found in many of the Lansing-Kansas City limestone oil fields. Sporadic drilling activity in southwestern Nebraska, prior to the Barger discovery, had yielded only non-commercial oil shows on the western flank of the Cambridge Arch. Exploration activity on the eastern flank of the Arch in Nebraska has yet to yield commercial oil except farther east in Harlan County.

During the past eight years, new oil reserves have been discovered from the Pennsylvanian and Cambro-Ordovician strata in Decatur and Norton counties, Kansas, located south of Red Willow and Furnas counties, Nebraska, respectively. Because of similarity in the regional structure and stratigraphy of southwestern Nebraska with the established productive areas south of the border, there is every reason to believe that the next few years will bring forth additional oil discoveries in southwestern Nebraska.

The regional stratigraphy and structure of the southwestern Nebraska region associated with the Cambridge Arch is based on a detailed analysis of deep well records filed with the Nebraska Geological Survey in Lincoln, Nebr. A structural map for the Base of the Kansas City limestone portrays the general subsurface relationships for the Pennsylvanian strata. (Figure 3) Permian, Jurassic and Cretaceous formations have a similar alignment which are modified somewhat in the younger strata. A generalized cross section along the southern border of Nebraska presents in profile the correlation of principal formational boundaries within the subsurface. (Figure 4).

Stratigraphy. The isopach map in Figure 5 shows the thickness and distribution of pre-Pennsylvanian strata of Mississippian and Cambrian sedimentary strata combined. Only a relatively small thickness of the Mississippian carbonates, in part Gilmore City equivalent, is present in southwestern Nebraska. Cambrian dolomites of the Bonneterre formation and LaMotte (Reagan) sandstone are present and overlie the Pre-Cambrian surface. Devonian, Silurian and Ordovician formations are not present on the southwestern flank of the Cambridge Arch but are truncated on the extreme eastern flank. A more or less continuous deposition of Pennsylvanian and Permian sediments occurs in the subsurface which are readily correlated for the most part on electric and radioactive surveys.

A remarkable similarity in the overall lithology exists within the Pennsylvanian limestones and shales which can be correlated through central Nebraska to the area of outcrop in the Missouri River area of Nebraska and Kansas. Jurassic sediments represented by the Morrison shale unconformably overlie the Permian section. Cretaceous sediments of the Montana, Colorado and Dakota groups are present in the subsurface. A thin Tertiary Age section mantles most of the area.

Locally, along the Republican River, Pierre shale of Cretaceous Age crops out intermittently. Exposed Tertiary rocks apparently do not reflect the structures and folding found in the older formations.

Structure. Examination of the structural map for the base of the Kansas City limestone reveals that the principal geologic feature involved in the area is the Cambridge Arch, which in general trends in a northwesterly direction from the Kansas border and continues in a southeasterly direction into Kansas. Sufficient exploratory drilling to basement rocks along the crest of the Cambridge Arch in Nebraska has not yet been completed to determine the exact area of divide between the east and west flanks. A pro-

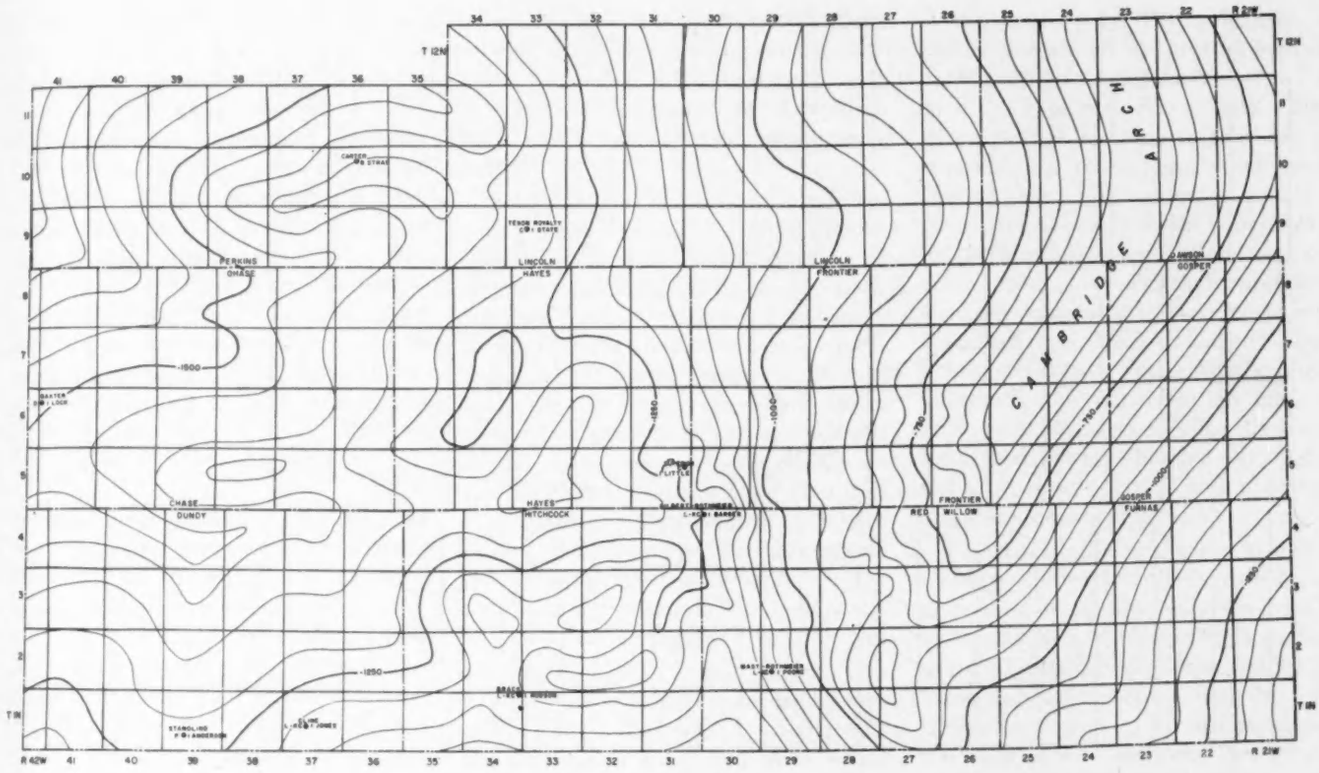

FIGURE 3—A structural map for the base of the Kansas City limestone portrays the general subsurface relationships for the Pennsylvanian strata. Contour interval is 50 feet. Cartography by H. L. Mall.

nounced change in directional trend in northeastern Red Willow County and Frontier County is poorly defined.

Regional dips on the Pre-Cambrian "granite" surface are generally west and southwest into the Denver-Julesberg Basin of Colorado. A map published by the Nebraska Geological Survey in 1957, entitled "Contour Map of Pre-Cambrian Surface in Nebraska" by E. O. Reed and R. F. Svoboda, portrays the relief on the Pre-Cambrian basement surface. Regional dips on the Pennsylvanian formations as exhibited by the structural map indicate the dip to vary from 10 to 30 feet per mile to the west with the lowest area in western Perkins County and northwestern Chase County.

Structural relationships in the Permian and Cretaceous beds reveal a similar development as in the Pennsylvanian formations that are somewhat modified in the younger strata. Shallow exploratory drilling to locate deep seated structures in the Pennsylvanian and Pre-Pennsylvanian would determine the more prominent structures. However, much of the Pennsylvanian oil accumulation is related to structures with little relief which may actually be stratigraphic accumulation.

Development of sufficient porosity and permeability within the Pennsylvanian limestones to create commercial oil accumulation is the most important factor in developing new productive areas. Improved production engineering techniques for recovery of oil in submarginal fields could promote greater exploitation of Lansing-

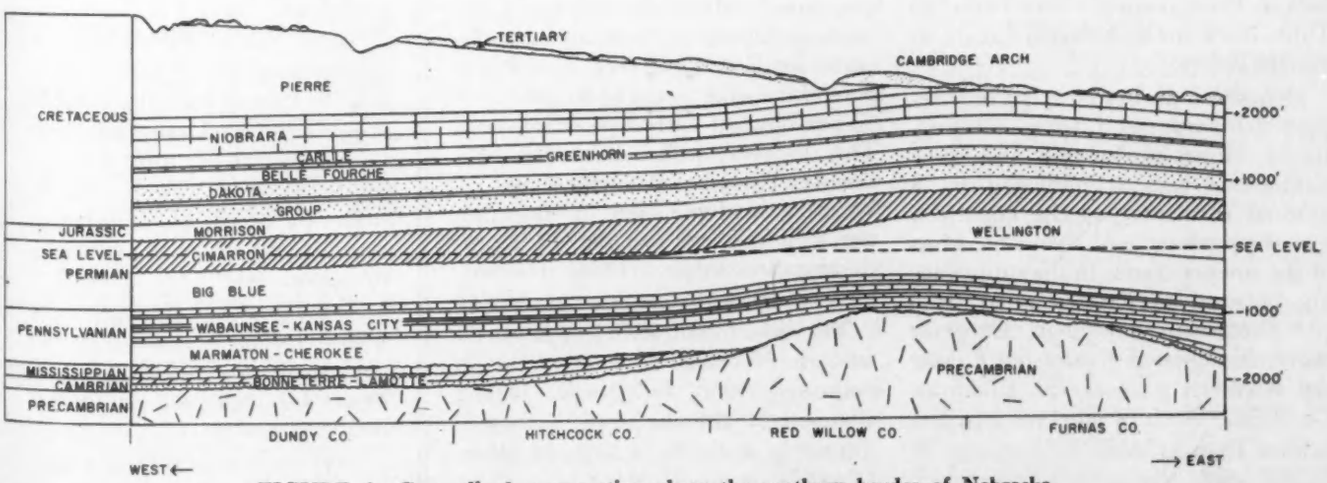

FIGURE 4—Generalized cross-section along the southern border of Nebraska.

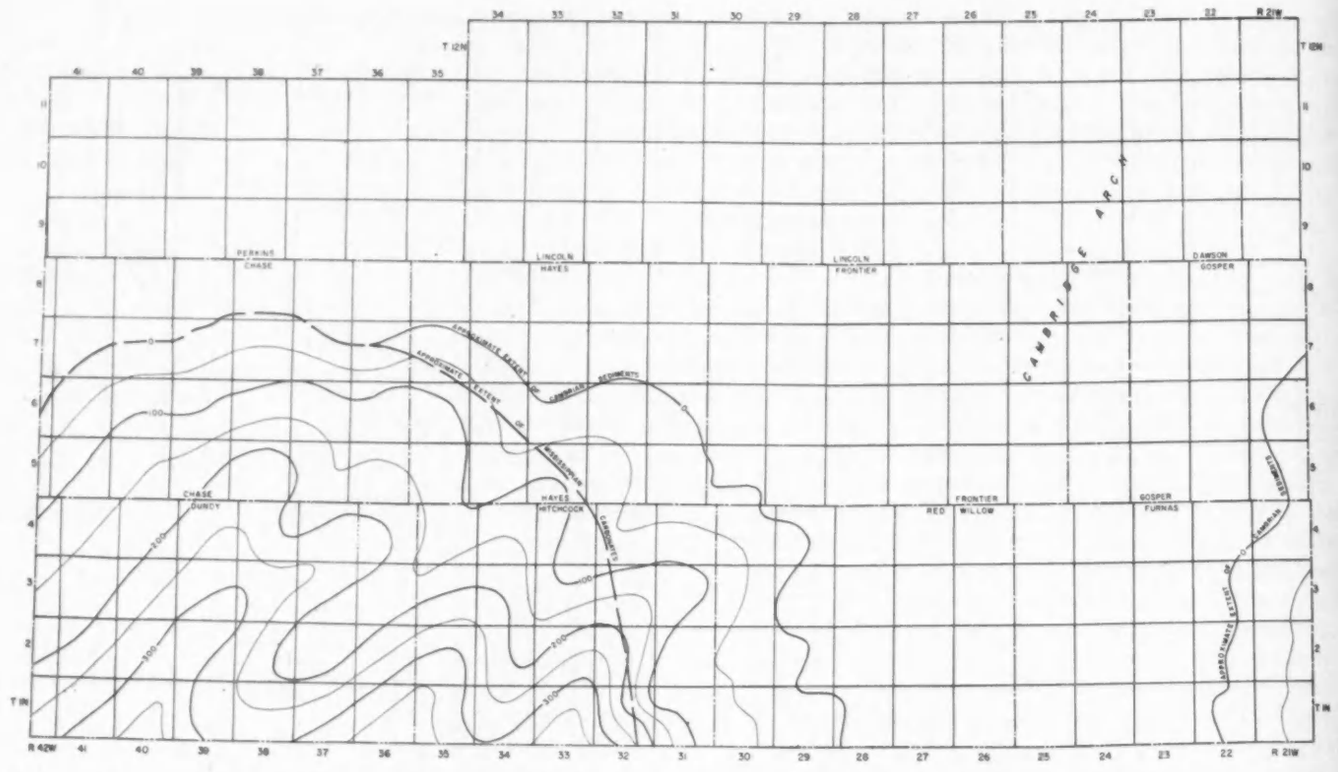

FIGURE 5—Isopach map showing the thickness and distribution of Pre-Pennsylvanian strata of Mississippian and Cambrian sedimentary strata combined. Contour interval is 50 feet. Cartography by H. L. Mall.

Kansas City limestone oil occurrence.

The early history of the Cambridge Arch appears to be associated with the development of the Central Kansas Uplift and ancestral Chatapaqua Arch and, in part, the Bourbon Arch of Kansas. Although some movements undoubtedly occurred along the Cambridge Arch before Mississippian time, the first major folding which can be readily identified is believed to be post-Mississippian in age. This is evidenced in the absence of all or part of the Cherokee, Marmaton and Kansas City groups over the higher parts of the Cambridge Arch in Nebraska. A similar chain of geologic events removed Lower Pennsylvania strata over the Table Rock Arch (Nemaha Ridge) in eastern Nebraska.

Deposition during Permian time reveals little orogenic folding or tilting. Broad tilting of Jurassic and some Cretaceous beds is indicated by a gradual thickening to the northwest into the panhandle of Nebraska. Most of the present trends in the subsurface are believed to have resulted from post-Cretaceous movement. Orogenic movement created greater relief along the northern part of the Chadron-Cambridge Arch in northwestern Nebraska than is now in evidence in southwestern Nebraska.

Recent exploratory developments. Subsequent to the discovery of the Barger field, a flurry of wildcat activity resulted in a second commercial oil discovery in Red Willow County by Mast Drilling Company and Joe Rothmeier in the Poore 1. Production is from two zones within the Lansing-Kansas City limestone at approximate depths of 3,640 and 3,680 feet. A confirmation well has not as yet been drilled to the discovery well, which reported an initial potential of 50 barrels of oil in ten hours.

In October, 1957, a rank wildcat discovery well was reported in Dundy County by the James M. Cline Oil Company with production from the Lansing-Kansas City at an approximate depth of 4,175 feet. The initial potential was reported at 60 barrels of oil per day cut with 5 percent water. This discovery well is located in Section 21, Township 1 North, Range 37 West on the Jones farm. A confirmation well has been completed for production and other activity is scheduled for 1958.

The most recent discovery in southwestern Nebraska was reported in February, 1958, by Brack Drilling Company at the Hudson 1, Section 1, Township 1 North, Range 34 West, Hitchcock County. Production from the Lansing-Kansas at an approximate depth of 4,082 feet was reported at 65 barrels of oil plus four barrels of water on an eight-hour test.

Drilling activity has picked up during the spring of 1958 with wildcats

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being scheduled in all the southwestern Nebraska counties. Nearly all of the exploratory wildcats in the southwestern Nebraska area have been drilled by small independent operators with some support from major oil companies. Major oil companies have been primarily engaged in lease plays through the southwestern Nebraska area. Discovery of oil from the potentially prolific basal Pennsylvanian sandstones or pre-Pennsylvanian in the area would set off a flurry of exploratory drilling such as that subsequent to the discovery of the Norton field in Norton County, Kansas.

Future exploration. The method for evaluating areas in southwestern Nebraska in the future will employ subsurface techniques including structural, isopach and facies studies. Location of stratigraphic type traps in the Lansing-Kansas City limestones must begin with a detailed knowledge of environmental conditions. Secondary development of porosity and permeability within the limestones is recognized as the primary factor for creating conditions suitable for commercial oil production in southwestern Nebraska. Unweathered outcrops studied in the eastern quarries of Lansing-Kansas City limestones along the Platte River of Nebraska indicate a remarkable similarity of depostitional environment and lithology when compared with subsurface exploratory well samples from southwestern Nebraska. The outcrops of Lansing-Kansas City limestones in eastern Nebraska exhibit a very low grade of porosity and permeability. Occasionally along the upper surface of a particular limestone, some porosity features appear which apparently were developed subsequent to deposition and prior to burial by succeeding sedimentation.

Southwestern Nebraska is an interesting area for future development, primarily, because of the number of objective potential oil producing horizons that can be evaluated within a depth of 5,000 feet. Cretaceous sediments which produce from the Dakota sands in the Denver-Julesburg Basin to the west and northwest are present in the area. Several wells in Chase and Perkins counties have reported encouraging oil shows from Dakota sands. A Cretaceous limestone above the Dakota sands is responsible for natural gas production in a field south of Wray, Colo., not far from the Nebraska border.

The Permian section in southwestern Nebraska has been bypassed and not thoroughly evaluated by most oil operators in their search for oil from Pennsylvanian and Pre-Pennsylvanian strata. A well drilled by Stanolind Oil & Gas Company in 1944, located in Section 28, Township 1 North, Range 39 West, Dundy County, had natural gas shows reported from the Permian section. Occasional shows of natural gas have been reported in other wells of Nebraska along the west flank of the Cambridge Arch as far north as McPherson County.

In the lower Cherokee Group section, several potentially good sandstones exist which have desirable reservoir characteristics. A very important showing of oil was reported by the Superior Oil Company from a Hayes County well, Section 12, Township 5 North, Range 31 West, in the basal Cherokee sandstone. Farther to the north in Lincoln County a well drilled by Texon Royalty Company, Section 16, Township 9 North, Range 33 West, had good saturation in a core taken from the basal Pennsylvanian sandstone.

The best chance for development of large petroleum reserves in southwestern Nebraska lies in the Mississippian and Cambrian formations which unconformably underlie the Pennsylvanian section. Truncation of Pre-Pennsylvanian beds and secondary weathering have created excellent reservoir conditions. The Norton field of Norton County, Kansas, in Section 36, Township 3 South, Range 24 West is the nearest Pre-Pennsylvanian oil production which has prolific reserves. Stratigraphic situations exist in Red Willow, Frontier, Hayes and Chase counties that are similar to those responsible for oil accumulation in the Norton field. The truncated wedge of Mississippian carbonates which overlie the Cambrian formations and underlie the Lower Pennsylvanian section are vulnerable to large petroleum accumulations. Near the western border of Nebraska and extending into Colorado, the Mississippian carbonates are believed to overlap the Cambrian beds which thereby offer additional prospects for oil accumulations along the unconformity.

Structurally, several areas in southwestern Nebraska offer promise of petroleum accumulation. A Carter Oil Company well, drilled in 1941 in Section 9, Township 10 North, Range 36 West, appears to be unusually high on the regional picture. In the environs of the crest of the Cambridge Arch, local folding may contribute prospective areas for petroleum accumulation. Along the edge of the Pennsylvanian-Pre-Cambrian contact embayments and erosional features in the Pre-Cambrian surface and beyond the limits of the Pre-Pennsylvanian beds may create suitable oil reservoirs. Several areas, as shown on the base of the Kansas City structural map, are now poorly defined but merit investigation.

ACKNOWLEDGMENT

The author wishes to acknowledge the assistance given by E. O. Reed, director of the Nebraska Geological Survey, and other members of his staff from whose files the majority of the basic data used to prepare this paper was obtained. The paper was originally presented before the spring meeting in 1957 of the Nebraska Academy of Sciences while the writer was associated with the Nebraska Geological Survey and was revised in the spring of 1958 for publication in WORLD OIL.

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About the Author

Richard F. Svoboda, petroleum consultant, specializes in the exploration and development of petroleum reserves. Before going into private business, he was with the Nebraska Geological Survey of the University of Nebraska as a petroleum geologist. Prior to that, Svoboda was with Northern Natural Gas Company as a petroleum geologist.

How you can keep your V-belts healthy

Periodic inspections and simple maintenance procedures can extend V-belt life and save you money

By D. A. Locke, Supervisor - Sales
Texrope Drive Department, Allis-Chalmers, Milwaukee

PROPER SHEAVE alignment, correct belt tension and simple maintenance procedures can mean considerable savings for operators using V-belt drives. Regular checkups on alignment, tension and sheave grooves will extend belt life, and such inspections can be made quickly and efficiently if field personnel have a basic knowledge of V-belt problems.

Properly engineered V-belt drives provide one of the most efficient and economical means of power transmission in the petroleum field. Yet, they require a minimum of maintenance.

One of the most common causes of excessive belt and sheave wear is improper alignment. It is important that driver and driven shafts be parallel so all V-belts will operate at right angles to the shafts. If this is overlooked, the V-belts on one side of the set are drawn tighter and will pull more than their share of the load. As a consequence, these belts wear out faster, and maintenance costs increase.

Several factors are indicative of improperly aligned sheaves. These are:

- Sheave grooves that are more highly polished on one side than the other.
- Belts worn more on one side than the other.
- Continuous squeaking.
- Overheated bearings.

Alignment can be checked readily by placing a straightedge or cord across the rim faces of the driver and driven sheaves. If they are properly aligned and shafts are parallel, the straightedge will contact the rim face at four points—two points diametrically opposite each other on each sheave.

Maintaining correct tension prevents whip and provides maximum sheave grip. Both over and under tension of V-belts can cause trouble. Over tension causes excessive bearing pressure. A loose belt can result in slip burn, snub breaks and ruptured cords in the grommet or plies. Insufficient tension often is the greatest hazard to belt life.

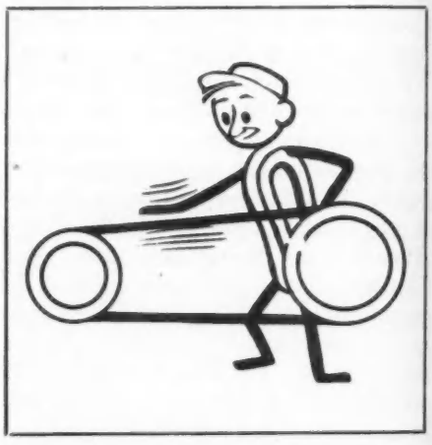
Proper belt tension is not difficult to determine. Apply moderate pressure to the belt at a point midway between the sheaves. A belt that can be depressed an amount equal to its own thickness for each 48 inches of unsupported length is considered to be properly tensioned. For practical purposes, the center distance of the driven can be considered as the "unsupported belt length" except where an idler is used.

To determine belt tension by slapping requires experience for the proper "feel." A correctly tensioned belt feels "springy" and "alive" when slapped by hand; a slack belt is dead and lifeless. It should be remembered that new belts need a breaking-in period. A certain amount of stretch occurs after belts have been installed so they should be checked regularly for tension during the first few days.

Sheaves also should be inspected regularly for burrs, rough spots or excessive groove wear. Grooves kept free of dust or foreign matter will prevent side wall wear and belts will maintain proper pitch line position and assure highest drive efficiency. Smooth sheave walls and proper belt tension assure maximum sheave grip thereby adding life to the drive. Periodic checks of sheave grooves with the proper groove template will disclose worn surfaces. Groove walls should be true and at the correct angle.

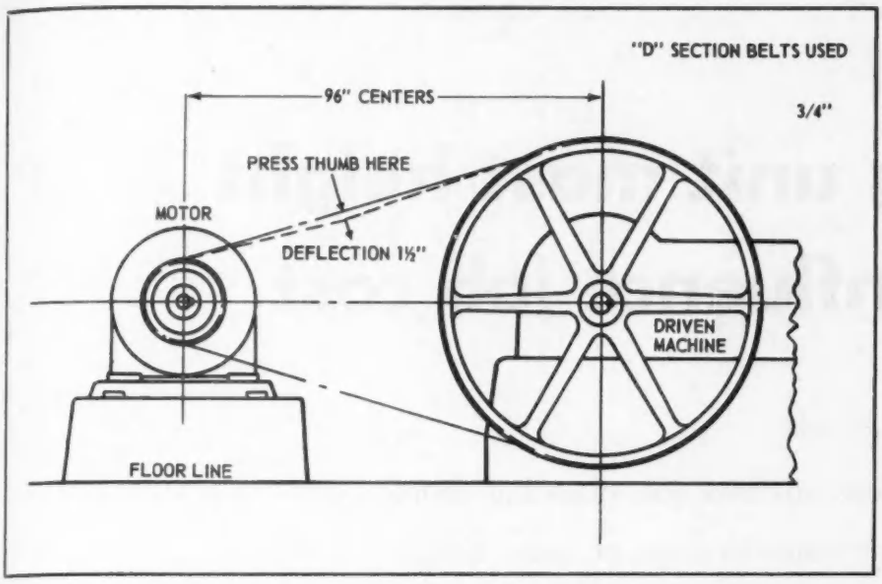
Check alignment

A straightedge or cord stretched across the faces of the drive and driven sheaves is a means of checking alignment. When properly aligned, the straightedge will contact the rim face at four points—two points diametrically opposite each other on each sheave.



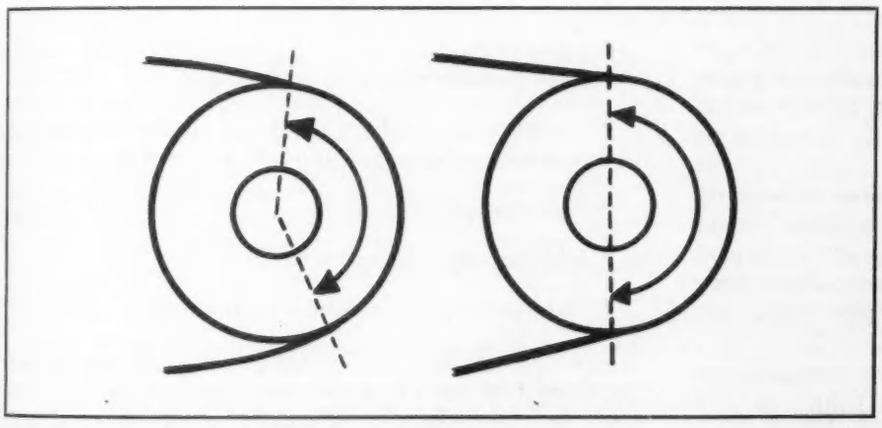
Determining belt tension

Slapping the belt sharply with the hand requires experience in getting the proper "feel." A correctly tensioned belt feels "springy" and "alive;" a slack belt, dead and lifeless. If a belt is too tight, it won't spring.



How to obtain correct operating tension

The deflection method is the best of several ways to obtain the correct operating tension on V-belt drives. With moderate thumb pressure applied to a belt at a point midway between sheaves, the deflection of the belt should equal its own thickness for each 48 inches of unsupported belt length. In this illustration, the deflection for the "D" section drive is: $^{96}/_{48} \times {}^{3}/_{4} = 1\frac{1}{2}$ inches.



Proper tension means maximum grip

When proper tension is maintained, a V-belt grips more of the sheave and grips it harder, adding life to the drive. This sketch shows how proper tension provides maximum sheave grip.

Oil is another hazard to belt life. When exposure to oil cannot be prevented, it is good practice to install oil-resisting belts. Clean belts in clean sheaves result in the greatest useful life from V-belts. This can be accomplished best by wiping belts free of grit and oil with a dry cloth *when the drive is at rest.* Under no circumstances is belt dressing recommended for V-belts.

It is advisable to remove all tension from belts connected to machines which are idle for extended periods of time. With bearing pressure removed, the lubricant breakdown between balls and races or between journal and bushings is avoided and the possibility of bearing oxidation is minimized. Also, with tension released, the belts do not tend to take a permanent "set."

Belts retain their usefulness best if stored in a cool, clean, dry area. They should be placed in bins or hung over wall pegs. Sharp bends which could result in a permanent "set" are to be avoided. Matching sets of belts should be tied together to avoid mismatching. This is important because V-belts in a multiple V-belt drive should not be replaced on an individual basis if the drive is to operate at its peak efficiency. —**The End**

Engineered completions

Continued from Page 179

pressure behavior at this point indicated all holes sealed.

CONCLUSIONS

- Selective perforating and reduced shot density decrease the tendency of the cement bond to disintegrate thereby reducing the possibility of communication.
- Communication is the major cause of fracture failure.
- Engineered stage fracturing used in conjunction with the above perforating theory will lead to more effective reservoir drainage, more efficient use of reservoir energy and greater ultimate recovery.
- Pressure behavior during a stage treatment can be used to calculate the efficiency of a fracture treatment.
- Savings up to 25 percent of present completion costs can be effected.

ACKNOWLEDGMENTS

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R. W. Coburn was educated at the School of Business Administration, Hofstra College and Tulsa University. He received a petroleum engineering degree from Tulsa in 1943. Following service in the U. S. Navy as a lieutenant j.g. during World War II, he joined the Atlantic Refining Company in 1946. He was employed by Atlantic as production engineer, district foreman, assistant district superintendent and drilling engineer. He joined Champlin Oil and Refining Company as district superintendent in 1953 and served in that capacity until Sept. 1, 1958. He is currently employed by W. E. Stiles Engineering Inc. as vice president and manager of field operations.

Pulling unit mast height can influence job cost

Efficient advance job planning should include consideration of mast height

By J. N. Gregory, Consulting Engineer
Long Beach, Calif.

A RECENT study in California underscores the importance of mast height in regard to job cost. More economical operations may result if mast height is considered during pre-job planning.

Of the many time-consuming operations in drilling, repairing and servicing wells, the time required to make a round trip cannot be avoided. The height of a mast or derrick is one of several factors which influence the time required to make a round trip. Three heights are in common use throughout the country:

- Masts or gin poles capable of pulling 30-foot singles usually are used for shallow to medium depth well servicing.
- Those capable of pulling 60-foot doubles are used for servicing shallow to deep wells, for repair work on shallow to medium deep wells and for drilling medium depth wells.
- Masts and derricks capable of pulling 90-foot stands are used for deeper repair work and most drilling below 5,000 feet.

Usually, the shorter mast goes with a small rig. The taller mast is used in conjunction with a heavier duty rig. Mast height should not be the only consideration when selecting equipment to service a well in the most economical manner.

Since a short mast is more easily moved and rigged up and is lower in initial cost and operating cost, it is worthwhile to evaluate the effect of mast height on the cost of pulling a well.

The time required to make a round trip of sucker rods, tubing, or drill pipe is composed of the following elements:

- Hoisting the load from bottom.
- Breaking out and racking each stand.
- Lowering the empty block for each stand.
- Handling drill collars, breaking out and making up tools and other work preparatory to returning to bottom.
- Lowering pipe to bottom.
- Stabbing and making up each stand.
- Raising the empty block for each stand.

In order to limit an analysis to the effect of mast height on round trip time, it is necessary to assume all features such as drawworks, power, number of lines strung and weight of blocks to be equal.

With this in mind, each stand of pipe handled will consume the following amount of time:

	30′ stands	60′ stands	90′ stands
1. Pull out of hole			
a. Accelerate and decelerate blocks	a sec.	a sec.	a sec.
b. Hoist load	b "	2b "	3b "
c. Break out and rack	c "	c "	c "
d. Lower empty blocks	$\sqrt{\frac{60}{u}}$ "	$\sqrt{\frac{120}{u}}$ "	$\sqrt{\frac{180}{u}}$ "
(u = acceleration of empty blocks)			
2. Run in hole			
e. Accelerate and decelerate blocks	e sec.	e sec.	e sec.
f. Raise empty blocks	f "	2f "	3f "
g. Stab and make up stand	g "	g "	g "
h. Lower pipe in hole	h "	2h "	3h "
Number of stands to be handled where D = Depth	$\frac{D}{30}$	$\frac{D}{60}$	$\frac{D}{90}$

Thus, ideal round trip time, exclusive of time out of the hole and time spent in inspecting, testing, or repairing while making the trip is:

For 30 foot stands:

$$T_1 = \frac{D}{30}\left(a + b + c + \sqrt{\frac{60}{u}} + e + f + g + h \right)$$

For 60 foot stands:

$$T_2 = \frac{D}{60}\left(a + 2b + c + \sqrt{\frac{120}{u}} + e + 2f + g + 2h \right)$$

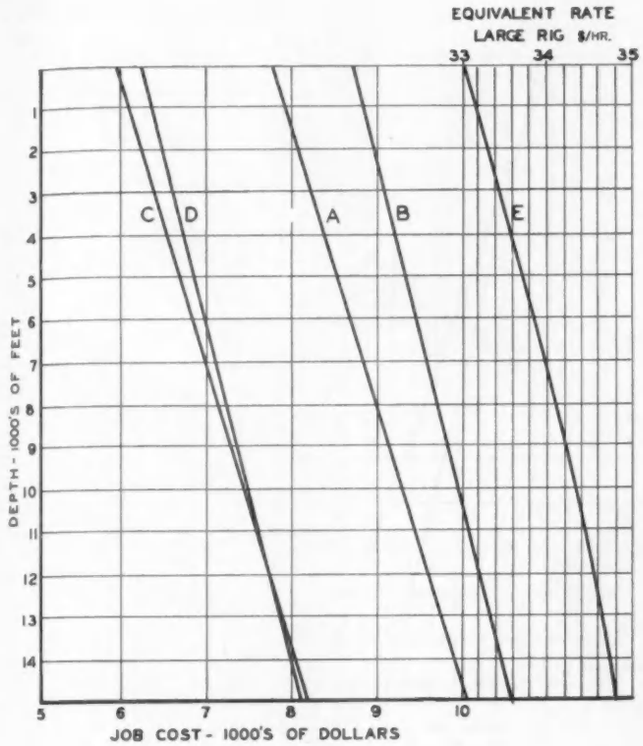

FIGURE 1—A typical example involving a pump change. The job consists of moving in, pulling rods, changing the pump, and returning the well to production. The following basic data are assumed.

	30-foot stands	60-foot stands
Move-in, rig-up, move-out	60 min.	90 min.
Out of hole replacing pump	30 min.	30 min.
Placing well on production	30 min.	30 min.
Round trip time	42 min./1,000′	27 min./1,000′

Curve A represents the time required to perform the job with a short mast; Curve B the time required with a taller mast. Because of the additional time assumed for moving in the larger equipment, the times will be equal for a well tubed at 2,000 feet. Curve C shows what rate a small rig is worth if the larger rig costs $27.70 per hour. Based on a typical difference of $3 per hour, the two would be equal at about 4,000 feet. Obviously, the greater the percentage of time spent in actual round tripping, the greater the value of the taller mast. For example, to pull an 8,500-foot well, it would be cheaper for the operator to pay $27.70 per hour (dashed line on Curve C) for a rig pulling 60-foot stands than to pay more than $22 per hour for a rig that pulls 30-foot stands. Above 2,000 feet, the difference in moving time makes the smaller rig more attractive (at the same hourly cost.)

For 90 foot stands:

$$T_2 = \frac{D}{90}\left(a + 3b + c + \sqrt{\frac{180}{u}} + e + 3f + g + 3h\right)$$

The difference in time for a mast handling 30-foot stands as opposed to a mast handling 60-foot stands will be

$$T_1 - T_2 = \frac{D}{60}\left(a + c + e + g + 4.54\sqrt{\frac{1}{u}}\right) \text{ seconds}$$

For 30-foot stands opposed to 90-foot stands:

$$T_1 - T_3 = \frac{D}{45}\left(a + c + e + g + 4.91\sqrt{\frac{1}{u}}\right) \text{ seconds}$$

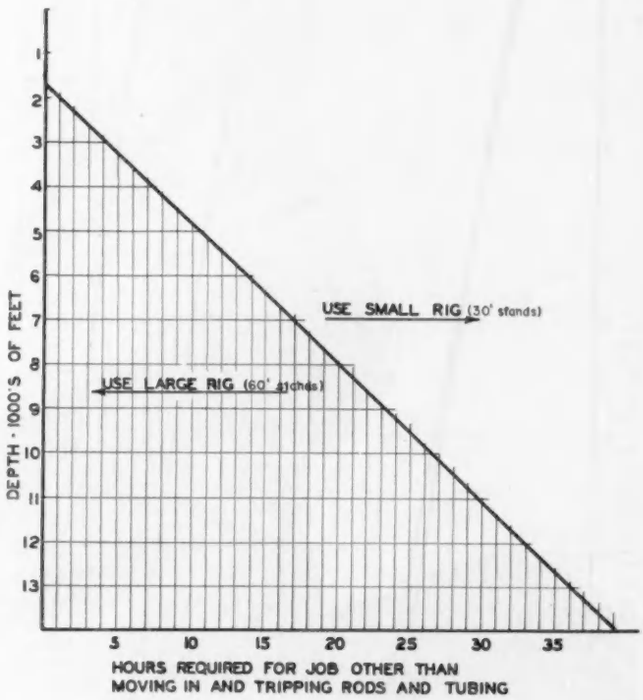

FIGURE 2—This figure illustrates a typical job consisting of moving in, pulling rods and tubing, bailing, running and testing tubing, running rods, and placing the well on production.

	30-foot stands	60-foot stands
Move-in, rig-up, move-out	60 min.	90 min.
Time making trip, rods and tubing	84 min./1,000′	54 min./1,000′
Rig and crew cost	$24.70/hr.	$27.70/hr.

The curve illustrates how a lengthy job justifies the use of a short mast. Since the tall unit has no time advantage except while round tripping, an extensive bailing job may very well justify the shorter mast. Considering an 8,000 foot well, if extra work such as bailing or perforation washing exceeds 20 hours, it would be more economical to use the shorter mast.

For 60-foot stands opposed to 90-foot stands:

$$T_2 - T_3 = \frac{D}{180}\left(a + c + e + g + 6.03\sqrt{\frac{1}{u}}\right) \text{ seconds}$$

There are too many variables affecting these factors to establish any absolute values for these formulae. Factors "a" and "e," the acceleration and deceleration of the blocks, depend on the engine horsepower, friction of the moving parts, transmission ratios, inertia of the moving parts, drum diameter, number of lines strung and the technique of the operator. Factors "c" and "g," the time required to break out and rack a stand and to stab and make up a stand, depend on the tools used and on the efficiency of a crew. The time required to lower the empty blocks depends on the weight of the blocks, the number of lines strung and the inertia of the moving parts.

In order that an appreciation of the magnitude of time involved can be realized, typical and reasonable values have been selected as follows:

a — acceleration coming out of hole	3	seconds
c — time breaking out stand	20	"
e — accelerations going in hole	3	"
g — time making up stand	20	"
u — acceleration of falling blocks	0.288	ft./sec./sec.

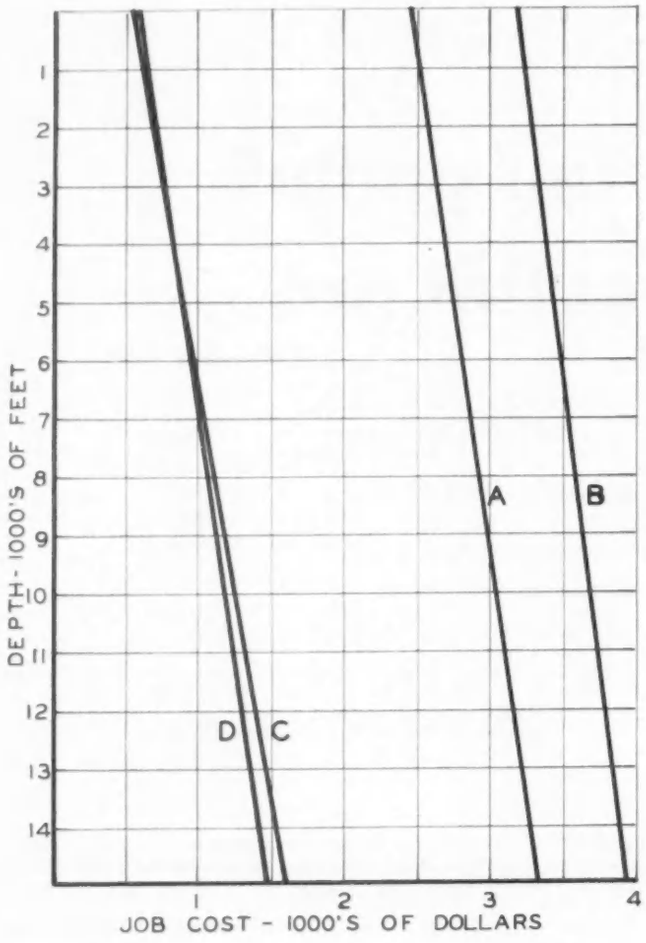

FIGURE 3—These curves assume a reconditioning job which will require 10 round trips with tubing and 180 hours of work either on bottom or out of the hole. For a comparison between pulling 60-foot stands as against 90-foot stands, assume the following:

	60-foot stands	90-foot stands
Move-in, rig-up, move-out	$1,800	$2,500
Time required for round trip	27 min./1,000′	22 min./1,000′
Rig and crew cost (include table, pumps, etc.)	$33/hr.	$34.50/hr.

Curve A shows the cost of the job for the rig with the shorter mast; Curve B that for the taller mast. Because of the difference assumed for moving and rigging up costs, the short mast shows to better advantage regardless of depth. If it is assumed that moving costs are equal, job costs will be as shown in Curves C and D, where the moving costs have been excluded, and where Curve C represents the shorter mast and Curve D the taller mast. Even here, the shorter mast is indicated to be advantageous. Of course, other features such as drawworks horsepower or the ability to rack the amount of pipe used may offset the advantage. Curve E represents the worth of the taller mast, assuming moving costs to be equal. Considering an 8,000-foot well, the job cost will be $9,000 (Curve A) if a mast pulling 60-foot stands is used. It will be $9,700 (Curve B) if a mast pulling 90-foot stands is used. Excluding moving, the work will cost $7,150 (Curve C) for the shorter mast or $7,250 for the taller mast. Job costs would be equal if the large rig cost $34.10 per hour and the moving costs were the same (Curve E). In other words, if a small rig can be obtained for $33 per hour, the large rig should cost no more than $34.10 per hour to be comparable.

which indicates differences having the following order of magnitude:

$T_1 - T_2 = 0.91D$ seconds per round trip
$T_1 - T_3 = 1.22D$ seconds per round trip
$T_1 - T_2 = 0.91D$ seconds per round trip

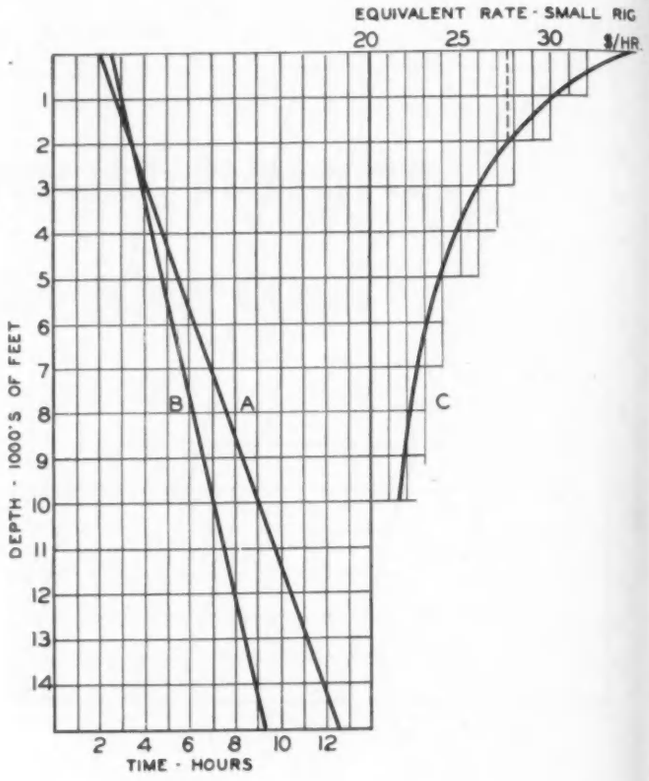

FIGURE 4—Here is another reconditioning job, similar to that illustrated in Figure 3. In this case, only four round trips with the tubing are required and there are 20 hours of additional work to be performed. Here the taller mast shows to some greater advantage since a greater proportion of time is spent making round trips. At best it equals only the cost of the job with the shorter mast if there is no substantial difference in moving and rigging up costs. (The same premium of $1.50 per hour is assumed for the taller mast). Again, for an 8,000-foot well, the job cost will be $2,925 (Curve A) for the mast pulling 60-foot stands and $3,575 (Curve B) for the mast pulling 90-foot stands. Excluding moving costs, the job would cost $1,100 (Curve C) for the short mast and $1,050 (Curve D) for the tall mast.

Converting this to minutes, it is apparent that:

- A mast pulling 60-foot stands should save 15 minutes per 1,000 feet of depth over a mast pulling 30-foot stands.
- A mast pulling 90-foot stands should save 20 minutes per 1,000 feet of depth over a mast pulling 30-foot stands.
- A mast pulling 90-foot stands should save 5 minutes per 1,000 feet of depth over a mast pulling 60-foot stands.

This study leads to a number of interesting comparisons that can be made between the costs involved in using various sizes of masts. Again, the many variables involved preclude presenting any absolute values. The accompanying illustrations are based on assumptions which are typical and reasonable but not necessarily applicable to any certain rig or job. Also, it should be remembered that differences in rigs other than mast height will have a very substantial effect on the pulling speed.

Advantages shown in the illustrations for the shorter masts could very well be eliminated in actual practice if the rigs were underpowered, traveling blocks were too light, or if one crew were more efficient than another. The illustrations do not take into account the value of

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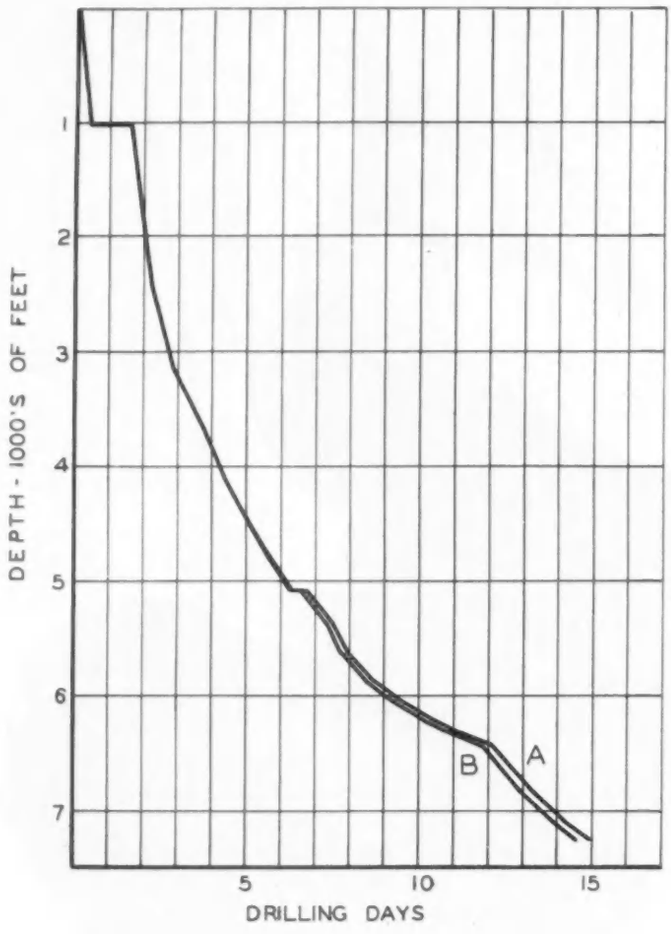

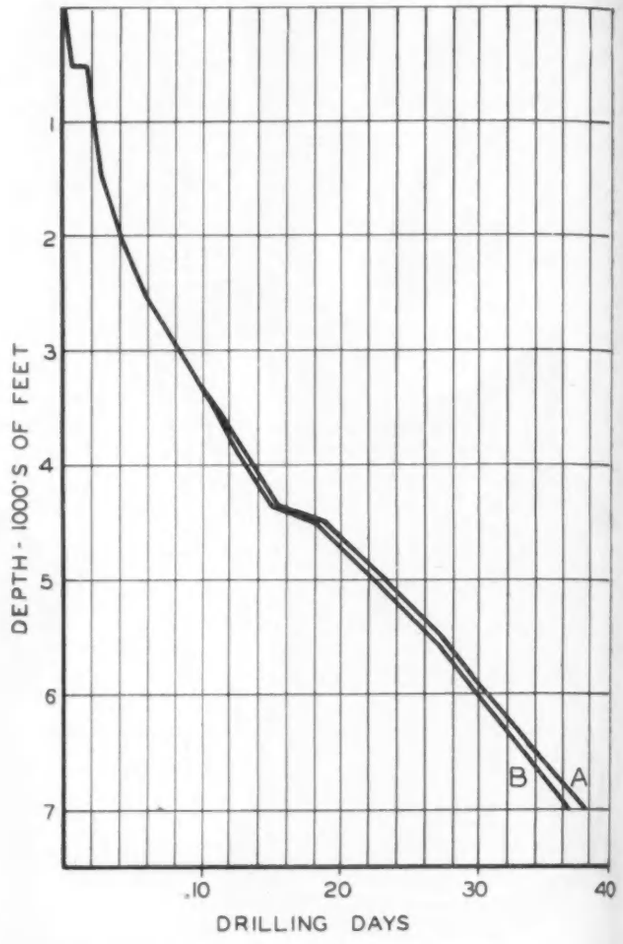

FIGURES 5 and 6—These curves illustrate the effect of mast height on the time required to drill two wells to a depth of 7,000 feet. Curve B in Figure 5 (left) represents the time required to drill a well with a mast handling 90-foot stands. Progress was relatively fast, total depths being reached in 14½ days using 19 bits. Curve A represents the progress to be expected had a mast pulling 60-foot stands been used. Here, since only a small proportion of time is consumed by round trips, the net increase in time required with a shorter mast amounts to less than 3 percent. Curve B in Figure 6 (right) represents a well drilled with a mast handling 90-foot stands where progress was slow. Total depth required 36½ days and 78 bits. Curve A represents what might have been expected with a mast pulling 60-foot stands. Here the difference in time amounts to slightly more than 3 percent.

time saved when down time means lost production.

The many variations that will occur in well programs and equipment preclude establishing any definite criteria for selection of a certain height mast. The illustrations shown, although based on field observation, are not necessarily industry-wide representative examples. They are intended to show the magnitude of time and costs that use of various types of masts represent.

An intricate prognosis of the work to be performed is hardly justified. It is seldom that any estimate of the time involved can be made with enough degree of certainty to justify the effort. However, rules of thumb may be established which usually will be accurate enough to use as a base in selecting equipment.

Following the time schedule used in the accompanying illustrations, these rules of thumb may be set up:

For rigs that are comparable in other respects, a mast capable of pulling singles will take about 55 percent longer to make a round trip than a mast capable of pulling 60-foot stands. A mast capable of pulling doubles will take about 23 percent longer on round trips than one pulling 90-foot stands.

These values, multiplied by the percent of time expected to be used in making round trips will equal the premium that the taller mast justifies if the two are to result in equal costs for the job.

Thus, a simple pulling job where round trips might consume 70 percent of the total time would justify up to a 38½ percent premium for a mast pulling doubles over a mast pulling singles. On a workover job where round trip time might consume 40 percent, the doubles rig would justify a premium of 22 percent over the singles rig, and a rig pulling 90-foot stands, would justify a 9 percent premium over the rig pulling 60-foot stands. On a drilling job where 20 percent of the time might be spent making round trips, the justification for a mast pulling 90-foot stands would amount to 4½ percent more than the mast pulling 60-foot stands. These premiums, of course, must also take into account any difference in moving and rigging up costs.

Although no absolute criteria for the selection of mast heights can be established, a little analysis and consideration of the job to be done often may result in substantial economies in accomplishing the work. **—The End**

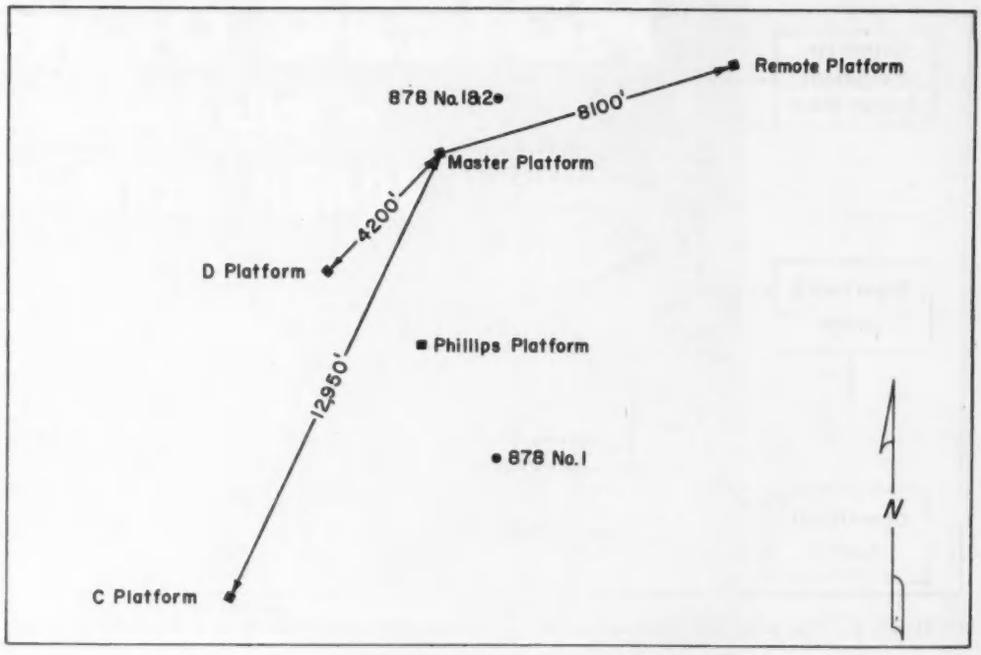

FIGURE 1—Relative positions of the remote and quarters or master platform are indicated. Rollover field is located 9 miles offshore from Vermilion Parish, Louisiana.

Offshore production aided by . . .

Microwave radio control developments

Significant savings are resulting from microwave control of gas and condensate production in the Gulf of Mexico

By V. L. Ackerman, Production Engineer, The Pure Oil Company, Houston
and W. K. Lewright, Production Engineer, The Pure Oil Company, Chicago

THE PURE OIL COMPANY recently installed semi-attended, microwave controlled production facilities in the Block 39 Vermilion field (Rollover field), nine miles offshore from Vermilion Parish, Louisiana. Apparent advantages of this initial installation are:

- Increased operational efficiency.
- Reduced marine transportation costs (one of the more expensive items of offshore production operations).
- Reduction in intangible costs (insurance rates, accident claims, housing etc.) in direct proportion to the decrease in direct costs.

It is estimated that operational costs would be reduced more than 50 percent if the system were expanded on a field-wide basis.

Pure's initial installation consists of a remote controlled platform approximately 1½ miles from the field quarters or control platform. At present, there are 14 gas wells in the field contained on four manned and two unmanned platforms. The average flow rate per well ranges from 2 to 10 MMcf per day. Production is separated and dehydrated in low temperature separation units. Gas and condensate are metered by orifice meters and pipelined to shore.

The control of three gas-condensate wells and their associated production equipment on the distant platform comprises the bulk of the telemetering and supervisory control. Initially, it was decided to make as few changes as possible in operational procedures, except to provide remote supervision, control and remote recording of sales measurement functions.

These measurement functions—seven for each of the three wells—are telemetered continuously and recorded at the control platform:

1. Gas differential pressure.
2. Gas static pressure.
3. Condensate differential pressure.
4. Condensate static pressure.
5. Gas temperature.
6. Condensate temperature.
7. Gas temperature at the choke.

An additional 12 selectively telemetered functions (four for each of the three wells) are indicated at the control platform on a multi-scale dial. These indicated functions are:

1. High pressure knockout pressure.
2. High pressure knockout temperature.
3. Temperature in top section of low temperature separation unit.
4. Temperature in water bath section of unit.

The continuously telemetered functions are used for sales measurement of the gas and condensate. In addition, the gas temperature at the choke is used for extraction efficiency con-

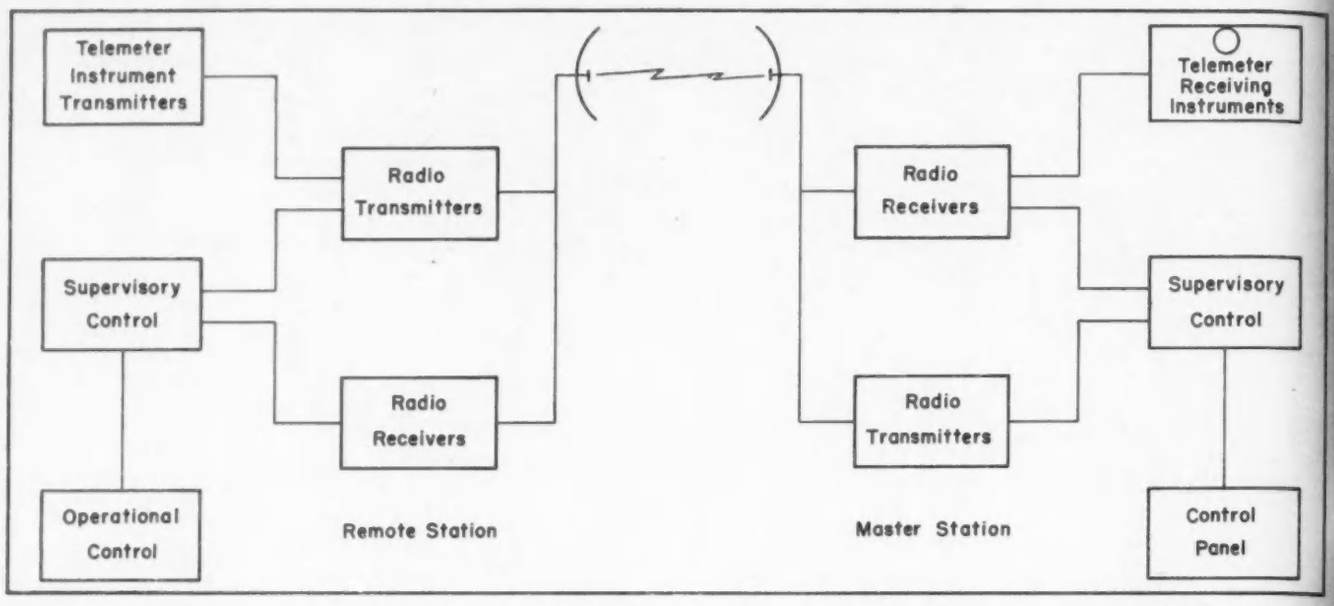

FIGURE 2—This schematic drawing shows the layout of the supervisory and control equipment used in Pure's Rollover installation.

trol. The selectively telemetered functions serve as guides in anticipating freezing of the units. This enables the operator to take appropriate action or minimize these malfunctions.

Type. Telemetering is of the analog, impulse-duration type. This type telemetering, though sensitive to frequency difference between transmitter and receiver, can tolerate considerable variation in signal strength level without affecting operation or accuracy.

The pulse in the receiver and transmitter are compared five times each minute, and appropriate action, if required, is taken.

As a change occurs in a variable (flow rate, temperature, pressure etc.), the transmitter indicator moves up or downscale as required. The amount of movement in the analog receiver pen arm will be dependent on the amount of change in the variable during the previous cycle (12 seconds).

The time duration of the transmitter pulse also is dependent on the amount of change in the variable.

There are 23 supervisory and supervisory and control functions provided for facilities at the remote platform. Included in this group are six alarm functions indicating malfunctions in production equipment. Included in the control functions are Christmas tree wing valve motor operators, simultaneous shutdown of the three pneumatic-operated master valves and the selective shutdown of the pilot-operated master valves. There are two master valves on each tree.

In the case of both master valves, control for shutdown is provided by de-energizing solenoid operated valves. Nitrogen provides a clean, dry, reliable source of energy for the pneumatic operators.

Other controls provide for "bleeding" of water from condensate, start and stop of foghorns and selective starting and stopping of the dual, diesel-driven generator units. To be certain that foghorns are operative, a resonant microphone pickup is employed. This indicates that the actual sound of the horns is being broadcast. The required aids-to-navigation platform lights long have been actuated by a thermal-operated "sunswitch." Also, they are equipped with individual battery power. Omission of control and supervision of these items was considered feasible due to the reliability of the control system.

"Fail Safe" features are an intregal part of the supervisory and control equipment. On loss of microwave signal or electric power, the equipment is returned to predetermined positions. On some valves, this is the "open" position; on others it is "closed." However, to prevent a premature shutdown, an adjustable time delay is provided for a severe "fade" in the signal level occasioned by severe weather or dense fog.

Somewhat of a problem was created since power of the transmitters is independent of the receivers, and both are engine driven units. The use of a "standby" unit with generators installed in pairs long has been practiced offshore. As previously mentioned, power failure on the equipment provides automatic shutdown. To prevent this, an automatic means of switching and synchronizing the dual units to the load was necessary.

Both engine units have primary protective devices to shut the unit down in the event of low oil pressure, high jacket water temperature and overspeed, any one of which will initiate a switchover of units.

Starting provisions. To provide reliable starting of the idle units, thermostat-controlled immersion type electric heaters are employed to keep the idle unit near operating temperature. This switchover (on tripping one of the primary protective devices) has brought the idle unit "on line," synchronized and carrying the load and dropping out the lead unit, in 20 to 30 seconds.

To provide further power reliability, a 5 KW emergency power unit is "riding" the main power bus, this provides transient power during switchovers and "smoothing out" of voltage fluctuations. The telemetering power supply input is taken across this unit, since it will provide voltage regulation even when acting as a motor (not providing power).

Considerable thought was given to the problem created by the sensitivity of the telemetering to frequency drift and the independent sources of power for the transmitters and the receivers. Some thought was given to the transmission of a square wave, 60 cycle-synchronizing pulse with a thyratron converter at the remote end. This was considered impractical because a

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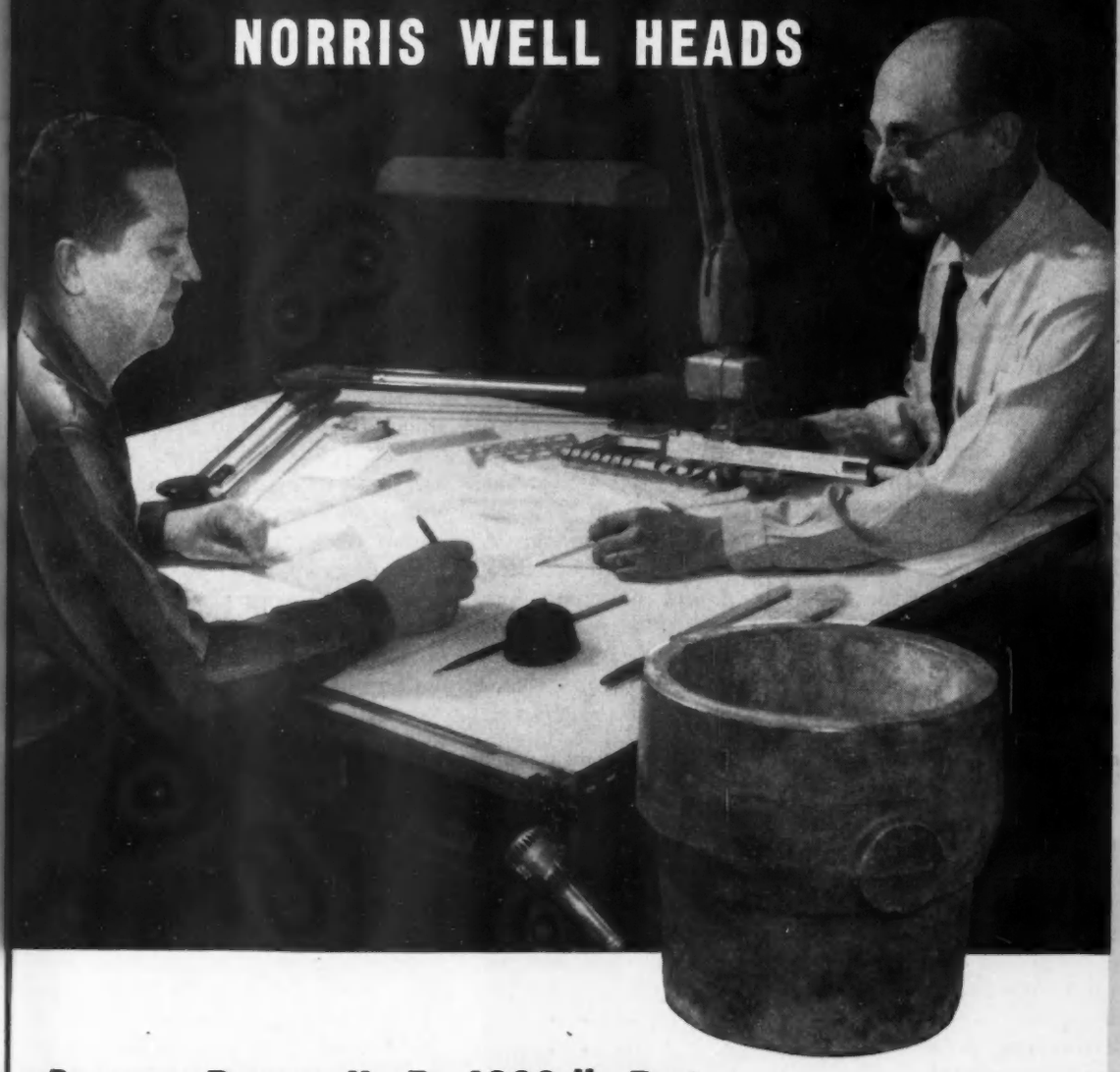

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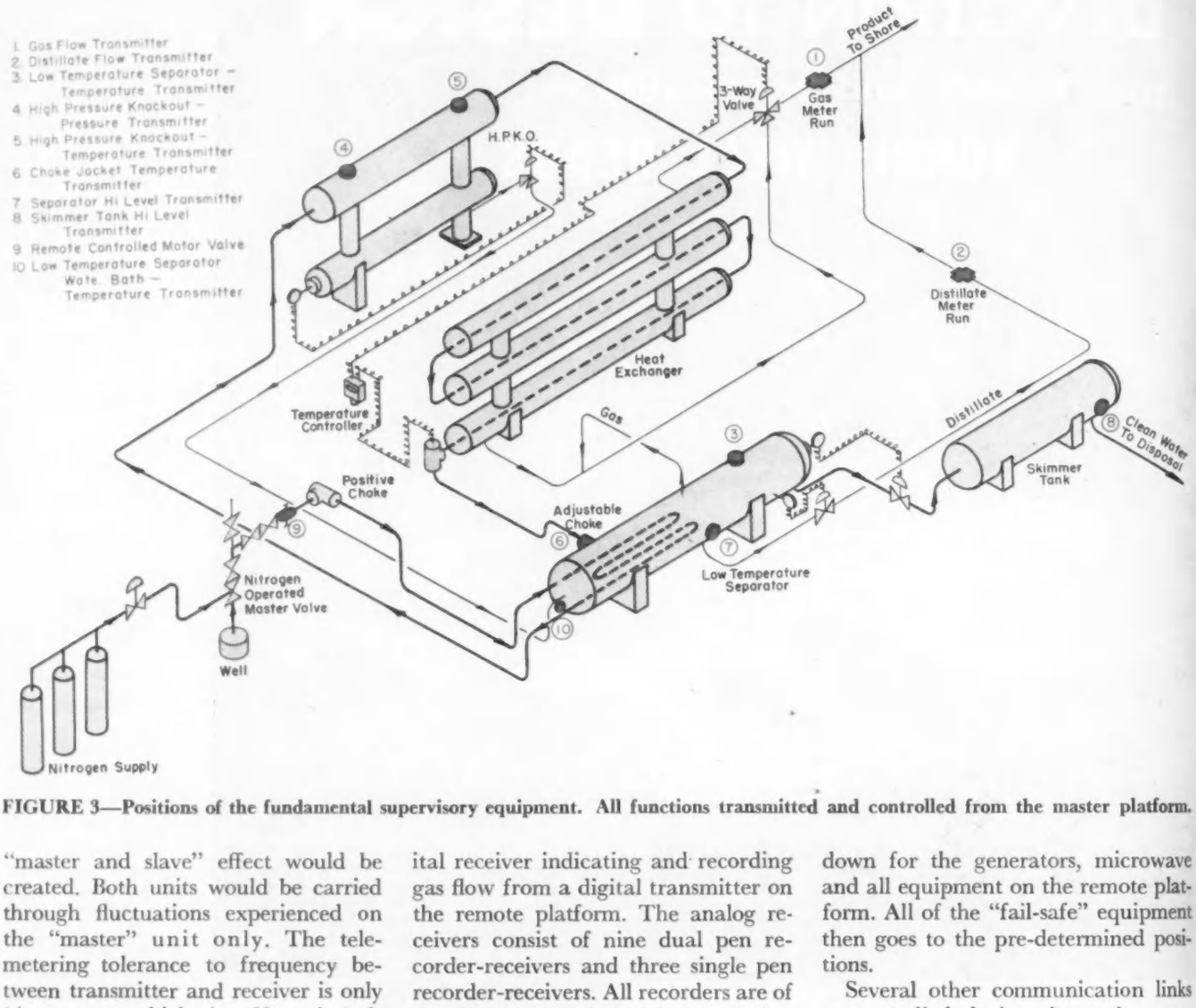


FIGURE 3—Positions of the fundamental supervisory equipment. All functions transmitted and controlled from the master platform.

"master and slave" effect would be created. Both units would be carried through fluctuations experienced on the "master" unit only. The telemetering tolerance to frequency between transmitter and receiver is only ½ percent, which (at 60 cycles) is less than half a cycle.

When the synchronizing pulse system was considered impractical, transistorized power supplies were developed To provide the lowest maintenance and the greatest amount of reliability, output of units are drawn from "ganged" individual units.

This arrangement reduces the power drawn from the individual units and increases life and reliability. (If any unit goes out, the remainder in the power supply will carry the load.) Specially constructed, miniature, temperature compensated forks provide the frequency control. Driven at 480 cycles, the output from these forks is divided by eight, to provide a 60 cycle output plus or minus 0.01 percent. This is better than the required ½ percent.

Installation. The analog telemetering receivers are installed at the control platform with the supervisory control panel. Also included is a digital receiver indicating and recording gas flow from a digital transmitter on the remote platform. The analog receivers consist of nine dual pen recorder-receivers and three single pen recorder-receivers. All recorders are of the 12-inch circular 24-hour rotation types.

The gas static and differential pressure, condensate static and differential pressure and gas and condensate temperatures are recorded on the dual pen charts. Gas temperature at the choke is recorded on a single pen chart. Selective telemetered functions are indicated only on a multi-scale dial, illuminated to indicate the proper scale for the function selected. A single graphic flow diagram is provided (non-illuminated to avoid confusion) as the flow diagram for the three wells is identical.

As mentioned above, the supervisory control panel is located with the telemetering panel, and is near the graphic flow diagram and indicating telemetering dial. Supervisory controls are the "select before operate" type in which the function desired must be selected before keying the operate switch, Included in these controls is a "crash" or master emergency shutdown for the generators, microwave and all equipment on the remote platform. All of the "fail-safe" equipment then goes to the pre-determined positions.

Several other communication links were studied during the early stages of this project, always keeping in mind that the system was to be readily expanded. Among the considerations was marine multi-conductor cable and the possibility of common carrier microwave equipment, neither of which was considered feasible for several reasons. The study revealed that microwave radio was the best, most economical choice for future expansion of the system.

Four channels provided. Four channels, with rack space for two more, are provided in the initial microwave system in the 6,000 MC range. Three channels provide telemetering and supervisory control while the fourth is utilized for two-way voice communication. The reliable klystron is used for RF energy in the microwave equipment and is guaranteed for 5,000 hours of operation.

However, experience data shows average life to be in the 10,000 to

Continued on Page 217

Production Viewpoint

ACT standardization can reduce costs

Future automatic custody transfer designs must provide for reliability and ease of trouble shooting. Competent maintenance service must be made available for good, long term performance

By H. L. Shatto,
Senior Mechanical Engineer
Shell Development Company,
Houston

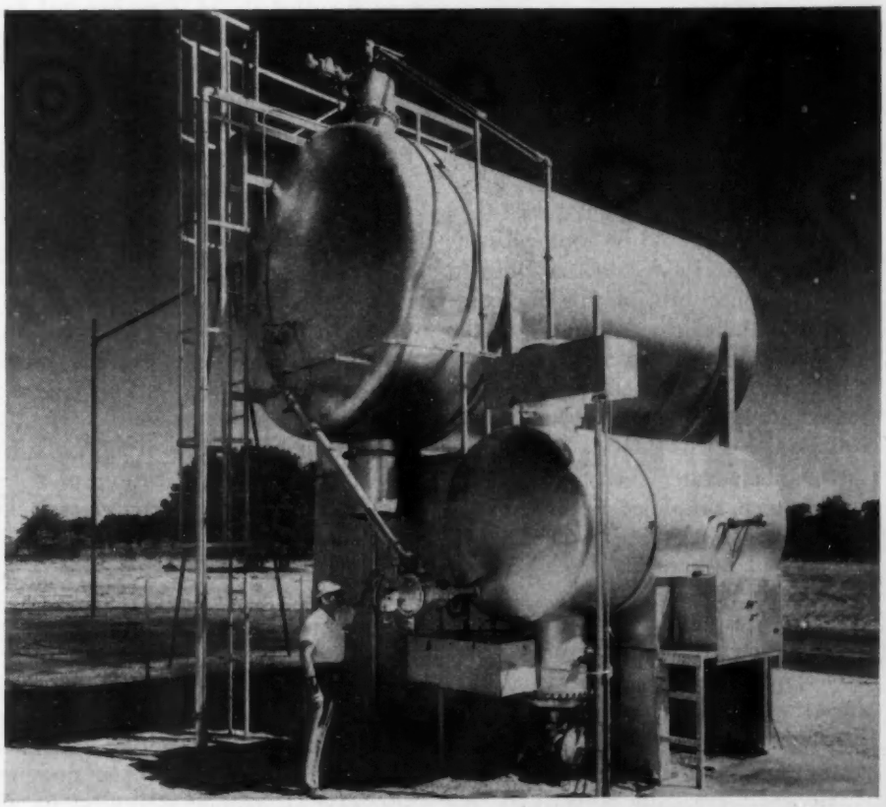
BECAUSE OF the strong economic incentive it offers, automatic custody transfer equipment now is coming into wide use. Work still is needed to facilitate the division of costs and responsibilities between producing and pipe line companies to reduce the expense of obtaining regulatory body approvals in some areas and to simplify and reduce the first cost of the installations. Future designs should be as simple and standardized as possible to facilitate maintenance by relatively inexperienced field personnel.

After a development period of more than 10 years, ACT is beginning to see extensive application. In a survey conducted early this year by the American Petroleum Institute Committee on Lease Automatic Custody Transfer, it was learned that 99 installations were to be completed by the middle of 1958. By extrapolation, the number of installations in the U. S. and Canada should reach more than 150 by year's end.

Although installations were of an experimental nature in previous years, a large percentage of those currently being installed are considered to be on a fairly routine basis. Next year should see this number again almost tripled with the majority of the 1959 installations entirely routine. While the principles of design and application of ACT equipment have demonstrated themselves to be satisfactory and while strong economic incentives will extend ACT use rapidly, there still is much work remaining to be done to facilitate routine use.

Incentives to producers. The important reason behind the rapid growth of ACT is the inescapable economic advantage which it offers in many cases. The economic incentives to both producing and pipe line companies were mentioned in some detail in the paper, "The Growth of Automatic Custody Transfer," coauthored by Adin Hall and the writer and presented March 31, 1958, at the annual API Pipe Line Conference. It was shown that ACT by PD meter was less expensive in first cost than conventional tankage on leases producing more than about 250 barrels per day. It also was shown that ACT by tank system was less expensive than conventional storage with production rates over about 600 barrels per day. Above these break-even points the cost advantage in the use of ACT can be considerable.

Even in those cases below the break-even point, where ACT is more expensive in first cost than a manual battery, there are other savings which sometimes are sufficient to pay out the additional cost. Reductions in evaporation losses averaging about 0.2 degrees API gravity and 0.5 percent in volume have been reported in favor of ACT. These figures are felt by some to be rather conserva-



There should be more than 150 automatic custody transfer installations in the U. S. and Canada by the end of 1958. This number is expected to be tripled in 1959. Due to these increasing numbers, new systems should be designed for ease of maintenance by relatively inexperienced personnel.

ACKNOWLEDGMENT
This article is based on a paper presented at the 13th annual American Society of Mechanical Engineers Petroleum Mechanical Engineering Conference in Denver, Colo., Sept. 21-25, 1958.

tive. In some cases, producers also may find savings of up to $200 per month per lease as a result of more efficient use of the lease operator's time. These savings are particularly significant where ACT would complete an otherwise fully automatic lease.

Finally, the savings which accrue to the pipe line companies also should be mentioned among the incentives to the producer, since these savings have induced many pipe line companies to assume part of the capital or operating costs. The portion of costs assumed by the pipe line companies is a direct added incentive to the producer which will extend the use of ACT to the benefit of the producing and pipe line companies alike.

Reducing installation costs. Attractive as all these economies are, there still is room for improvement. Many installations that have been made have cost much more than they should have and frequently much more than the direct capital costs would indicate.

A large share of the costs that remain unaccounted for is found in the negotiations preceding operational use of an ACT system. This includes:

- Diccussions of equipment design usually with some re-engineering.
- Planning for and running performance tests.
- Settlement of the division of responsibilities and of capital and operating costs between producing and pipe line companies.

While these costs might be expected to be high during transition from experimental to operational use, they now can and should be reduced considerably. Basic minimum design standards published by pipe line companies and policies setting out the acceptable division of costs and responsibilities have been effective in reducing these costs and facilitating routine use of ACT.

One such statement of policy has, for instance, simplified negotiations in the Four Corners area where about 90 percent of the oil now is run by automatic custody transfer. Policies covering cost allocations are considered somewhat tentative until more is learned about the operating savings that will be realized by pipe line companies. They are helpful, nevertheless.

In some areas the process of obtaining regulatory body approvals for the use of ACT is time consuming and expensive. This added cost probably has been as high as 50 percent of the capital cost of some individual ACT facilities—and maybe higher.

In many areas there are no regulations which restrict the use of ACT equipment. In others, the regulatory bodies have granted rather simple blanket approvals. Some progress already has been made in simplifying these procedures. As this equipment becomes more familiar, it is expected that requirements will eventually be eased. The establishment of minimum standards for the industry through such organizations as the API may be of help in this regard. In the meantime, this subject merits attention as a source of cost reduction.

Some further possibilities for cost reduction lie in system design. Future field experience with meter ACT systems may demonstrate that satisfactory installations can be made without the use of gas eliminators and possibly even without the meter charging pumps now generally used. With increased use and resulting mass production, some reduction should be seen in the cost of the dielectric monitors which are used to prevent shipping gross quantities of water to the pipe line. In many cases simple type monitors could be used in place of the recording models which were useful primarily in experimental systems. Some reduction in cost also might result from simplifying the entire piping system and mounting arrangements.

Provisions for maintenance. Automatic custody transfer already has strong economic justification. Any improvements made through work along the lines mentioned above will increase the rate at which it is being used. In view of designs now going into routine application and considering the lack of maintenance service available, it is questionable whether industry is as ready as it might be for the large scale application of these facilities which their economics seems to dictate.

Many new ACT systems being installed show little difference in packaging and arrangement from those earlier considered experimental. For the most part, circuits for these systems (particularly the PD meter types) are rather simple. However, usually they have not been designed for ease of trouble shooting by inexperienced personnel. Trouble shooting must be done by competent electricians. In some cases it is still done by the engineer who designed the system.

A well-engineered and tested design with assemblies arranged for easy performance checking is expensive. Such high quality designs cannot be justified if each system installed is different from previous designs. Even if such designs were economical, a large number of such systems still presents a training problem for maintenance personnel.

It has been hoped that this situation would be relieved by a natural trend toward purchase of systems standardized to some extent by the manufacturers for lower selling cost. Several off-the-shelf systems are now offered.

The trend toward their use has been slow in developing, probably for several reasons. First, most of them appear to cost more instead of less than equivalent user-designed systems, unless very high hidden costs are assumed for the homemade systems. Another possible reason is that this new field has inspired an inventiveness which creates new features or combinations of old features that the standard units cannot yet provide without some re-design. As a result many manufacturers are content to assemble the steady stream of new user-design systems. Maintenance problems created by the large number of different systems continues to grow.

This surge of inventiveness certainly is welcome in the field of crude oil measurement, and development work should of course continue. However, the rate at which ACT systems are being installed indicates that operators should avoid treating each new installation as a research project. They should be more insistent that designs be simple and arranged for easy long term maintenance.

If systems now being installed were designed for ease of maintenance, it is likely that adequate trouble shooting could be handled by relatively inexperienced local company or contract personnel with little special training. If this were coupled with availability of a minimum number of standard spare components, prompt factory repair service and a little preventive maintenance by contract or company personnel, results should be very satisfactory. Until such conditions prevail, more highly trained personnel will have to provide necessary routine maintenance for the many various systems now being installed.—**The End**

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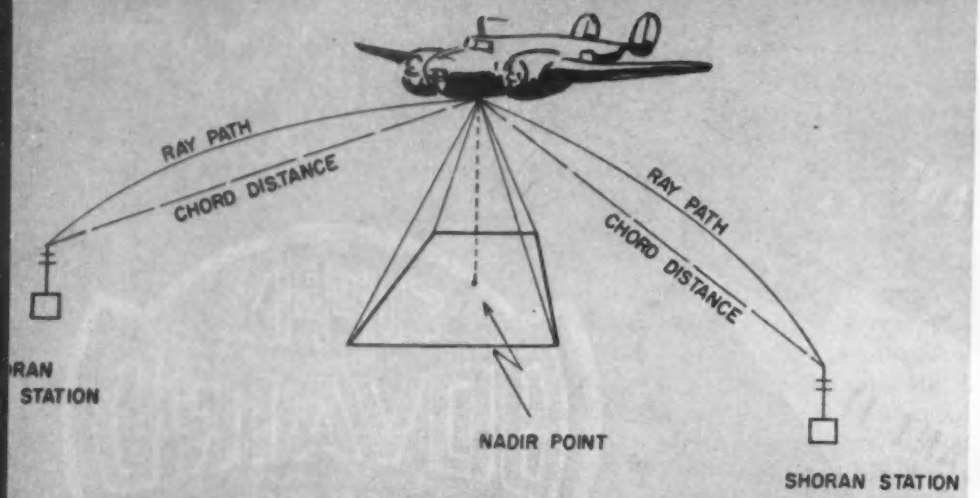

FIGURE 1—Electronic equipment establishes the position from which an aerial photograph is taken.

Surveys made from air aid remote exploration

Geological and geophysical mapping from air facilitates search for petroleum in places inaccessible. Mapping without ground surveying is achieved through use of aircraft, together with aerial photography and electronic survey techniques

By M. E. Erfle
Canadian Aero Service Ltd.
Calgary, Alberta, Canada

IT IS NOW possible to compile accurate topographic maps and to establish the position and elevation of any point on the earth's surface without actually setting foot on the ground. In this way the search for petroleum is greatly aided in remote and inaccessible places.

The mapping without ground surveying is achieved through use of aircraft, together with the science of photogrammetry and electronic survey techniques, such as Shoran and Radio Altimetry.

These methods of exploration are proving their worth in such remote areas as the North of Canada and the tropical lands of Guatemala.

Photogrammetry is a branch of civil engineering and is the science of obtaining surveys by means of special aerial photographs. Its aim is to reconstruct precisely the dimensions of two- or three-dimensional objects from photographic reproductions. The photographed object is usually the earth's surface. The task is to compile a topographic map or to establish the position and elevation of some selected points in the area of interest.

For this purpose the vertical aerial photographs are flown with 60 percent forward overlap and approximately 30 percent side overlap between the flight lines, using precise aerial cameras equipped with high resolution and distortion free lenses. The photographs are taken at altitudes ranging from 1000 to 35,000 feet, depending on the type of project for which the photographs are intended.

In the areas of common overlap of the successive aerial photographs, hereafter referred to as a "model", the terrain can be viewed in three dimensions using a simple stereoscope. If the pictures are placed in a precise stereoplotting instrument, so that their absolute position and orientation in space at the moment of exposure is precisely reconstructed, then every point of the viewed model can be accurately measured in position and elevation and plotted in the form of a map showing contours, spot elevations and planimetric details.

Some areas of the north are not as yet covered by vertical aerial photographs—only by old trimetrigon photography. The trimetrigon photography is flown using three aerial cameras coupled together. One camera takes vertical pictures, and two take oblique pictures in the direction perpendicular to flight. The oblique photographs cannot be used as conveniently as the vertical ones, since the scale is not constant and straight lines are distorted. The ground close to the horizon is photographed at a smaller scale than the ground beneath the airplane. Therefore, it is sometimes the case that when maps are required for exploration work, trimetrigon photography is the only available photography of the area.

It may be impossible to fly new vertical photography because of the time of the year, length of time required to mobilize the aircraft to take the pictures or because of economic considerations. To meet these conditions the possibility of using existing oblique photographs for compilation of accurate topographic maps has been explored. As a result of research work, the plotting instruments have been modified to accommodate oblique aerial photographs, and methods have been developed which make it possible to compile 25 foot contoured maps to standard accuracy from trimetrigon photography.

Electronic Instruments. To establish the position of aerial photographs during a survey flight, electronic instruments can be used to great advantage. For example, Shoran gives the horizontal position of each individual photograph at the moment of exposure,

while the Radar Altimeter measures and continuously records the profile of the ground.

The basic Shoran equipment consists of a pulse generator, a transmitter, and a receiver installed on the airplane, and a receiver coupled to a transmitter at each ground station. The airborne set accurately measures the elapsed time between the moment in which a pulse is transmitted to the ground station and the moment in which the return pulse is received. This time interval is recorded in terms of equivalent miles and fractions.

For photogrammetric mapping of any large area, a net of primary geodetic points is required. In inaccessible areas geodetic points can be established by Shoran trilateration more rapidly and economically than the classical triangulation method. These points are usually in the order of 200 miles apart. In Shoran Trilateration distances are measured instead of angles. The distances between points are measured by using the "line crossings" procedure.

The aircraft flies across the line to be measured at its midpoint and records simultaneously at short intervals the distance to each of the ground stations. The distance between ground stations *A* and *B can be determined as the sum of* a + b, when a + b is a minimum. Using this method distances can be measured with a relative accuracy of 1/100,000. After the basic net of horizontal control is established, the position of each individual aerial photograph is determined by using Shoran in the following manner:

Two Shoran ground stations are located at previously established geodetic stations. An airplane equipped with an airborne set, synchronized to an aerial camera, takes aerial photographs over the area to be mapped. The moment the aerial camera exposes a picture, the Shoran dials are photographed. These dials indicate the slope distance from the aircraft to each station.

Knowing the coordinates and elevation of the ground stations, the distances from the airplane to the ground stations, the altitude of the airplane, and the atmospheric conditions, the Shoran distances can be reduced and coordinates computed of the nadir point of each aerial photograph. The accuracy of the coordinates of the nadir point of each individual exposure can be improved by applying photogrammetric techniques, combined with a least square or graphical adjustment.

Radar Altimeter. Usually, the aircraft carries radar altimeter equipment besides the aerial camera and Shoran. The radar altimeter technique is relatively simple. During a survey flight electro-magnetic pulses are transmitted downward, reflect from the ground surface and are received in the airborne set. The instrument measures precisely the time elapsed between the moment in which the pulse was transmitted and the moment in which the pulse is received after reflection from the earth's surface.

Since the speed of propagation of electro magnetic waves is known, the distance from the airplane to the ground can be easily determined. This is usually recorded as a continuous profile of the ground. This profile is corrected automatically for the deviation of the aircraft from an isobaric surface by the use of a very sensitive electronic aneroid. Since the isobaric surfaces are not parallel to the geoid, the profile of the ground must be adjusted.

In Canada the electronic survey methods are used by the Department of Mines and Technical Surveys to establish the preliminary net of geodetic control points and elevations for mapping and also by private mapping organizations to establish secondary control for photogrammetric mapping of Canada's North.

The first commercial operation of this kind in Canada was conducted in the summer and fall of 1952. Since 1952 Shoran operations have been carried out during the operational season of each year. Shoran controlled aerial photography has been flown at an altitude of 20,000 feet (at a range of approximately 200 miles from each Shoran station) along each degree of longitude and each 20 miles of latitude. As a result from 1952 through 1956 an area of some 600,000 square miles was covered by a relatively dense grid of points whose geographic co-ordinates are accurate to within ±100 feet.

To extend the horizontal control in the areas located between the lines of Shoran controlled photography, photogrammetric bridging or slotted template methods can be employed, depending on the accuracy required.

Based on the points established by Shoran, the geographic position of any point of interest can be determined in a small fraction of time and for considerably less expenses, than would be

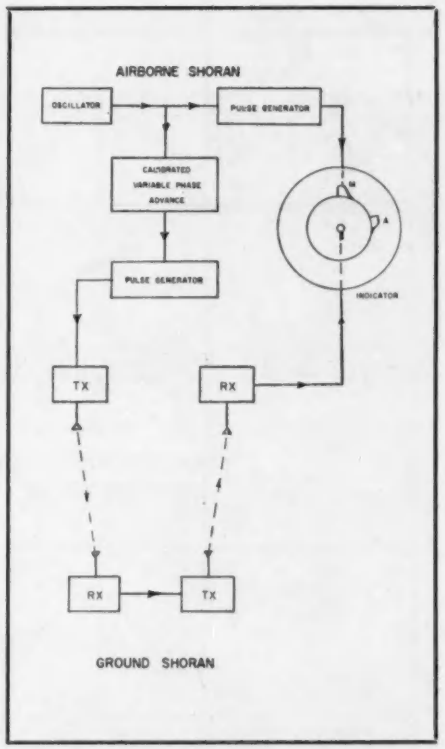

FIGURE 2—Basic Shoran equipment consists of a pulse generator, a transmitter, a receiver installed in the airplane and a receiver coupled to a transmitter at each ground station.

possible using ground survey methods, without the necessity of ever setting foot on the ground.

The geographic position, and in many instances the elevation of a point of interest, can also be determined in areas covered by a triangulation net. For this purpose specially developed photogrammetric bridging methods are used, which make it possible to extend precisely the coordinates and elevations over unsurveyed areas. This is more involved than in areas covered by Shoran controlled photography.

Use in Exploration. It is evident that the information obtained by photogrammetric and electronic survey methods has a wide application in exploration work.

Aerial photographs contain valuable information concerning geology, and can be used to great advantage for broad or detailed planning of all types of exploration work.

Base maps to meet any requirement in exploration can be prepared economically from vertical or trimetrigon photography. The requirement for good base maps is critical in any area where reasonably large scale maps are not available. Even though the various governments have made maps at scales of 1 inch equals 1 mile or

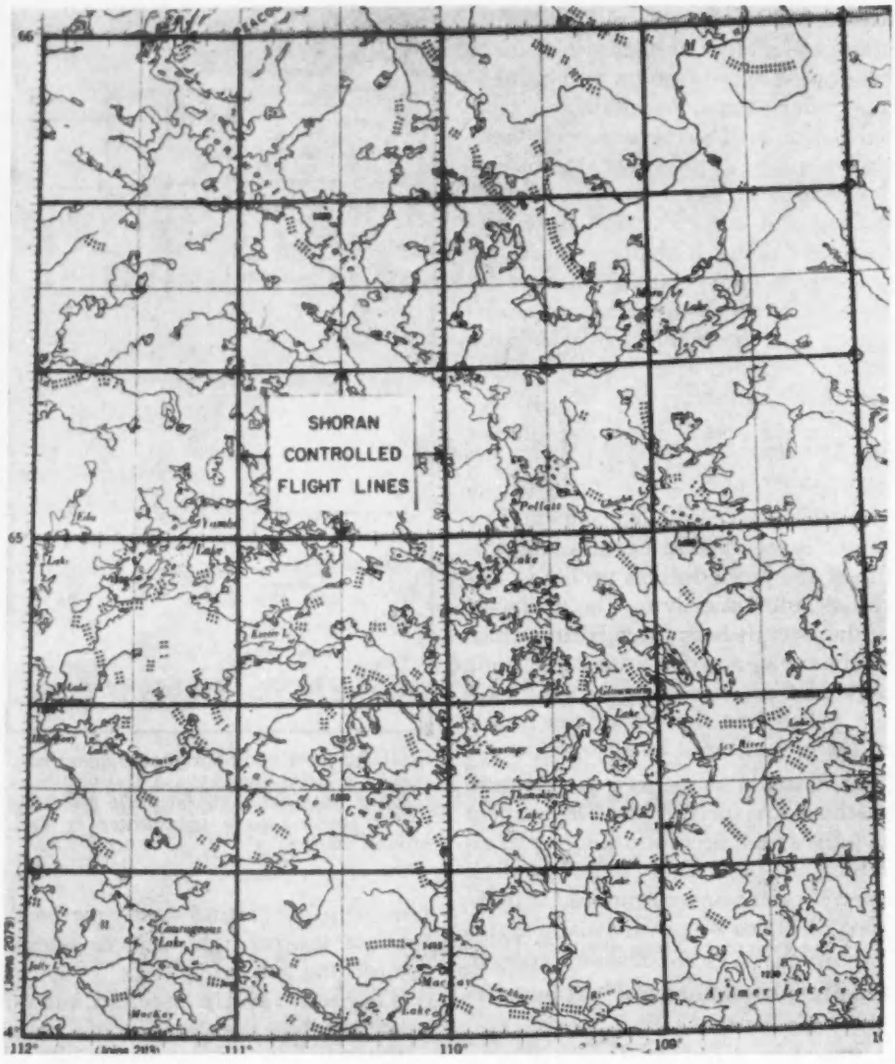

FIGURE 3—When planning exploration work in northern Canada, consideration should be given to the application of electronic surveys and photogrammetry. A considerable area in the region is well covered with Shoran controlled photography.

smaller, more accurate base maps can be made from existing information without recourse to further field work or photography.

Photogrammetric methods can also be applied in photogeology to prepare geological maps and to determine elevations, strikes and dips of geological structures. These accurate measurements can be used to extrapolate geological formations over areas where they cannot be seen by a direct inspection.

In gravity surveys photogrammetry can also be used to advantage.

(a) To determine spot elevations of gravity stations, methods are being developed which will permit economical establishment of relative elevations at gravity stations with a probable error of ±1 foot and without the necessity of procuring expensive ground control.

(b) Using existing Shoran controlled aerial photography, it is possible to combine scattered local areas of gravity surveys into one co-ordinate system, determine distances between these areas, or to establish the absolute position of selected points with a probable error of ±100′.

(c) To determine the terrain correction, accurate topographic plans can be compiled on an arbitrary horizontal and vertical datum, so that all required quantities can be obtained.

These applications may greatly increase the use of gravity surveys for exploration in the unsurveyed and bush covered areas of Canada, by making it possible to operate without ground surveying and by removing the need for barometric surveys in conjunction with helicopter borne gravimeters.

Seismic Work. Photogrammetry and electronic surveys can also aid in seismic work. Its first application is in planning the seismic program. Detailed access studies can be made to best utilize existing cut lines and to lay out other required survey lines in order to minimize the amount of heavy cutting necessary to successfully and economically complete the program.

When refraction seismic is used, the photogrammetric methods can be applied to advantage for determination of horizontal position and elevation of the shot points and geophones, and for the determination of the distance between the shot point and geophones. These distances can be computed with a relative accuracy of 1/10,000, and elevations of geophones and shot points can be easily determined, using existing photography, with a probable error of 5 or 10 feet, depending on scale of photography.

When reflection seismic is used, all reconnaissance scattered cross-spreads can be tied into one system vertically and horizontally. Here again Shoran controlled photography and photogrammetric bridging methods are applied.

Determining Locations. In areas covered by Shoran photography, all concession boundaries can be readily defined by geographic co-ordinates, and geographic positions of wells can be quickly determined.

Presently a combined Shoran-airborne magnetometer survey is being conducted in Guatemala. The magnetometer survey flights are controlled by Shoran for the purpose of recovering the flight path and also to determine the concession boundaries.

Aerial survey techniques can be employed to great advantage in spotting the well locus in difficult areas, making gathering line layouts, and locating pipe lines and roads.

When planning exploration work in northern Canada, consideration should be given to the application of electronic surveys and photogrammetry.

Since a considerable area in the Northwest Territories is amply covered with Shoran controlled photography, this information is immediately available, any survey problems within this area can be accommodated quickly and economically.

ACKNOWLEDGMENT

Presented originally at the C. I. M. M. annual meeting at Edmonton, May 8, 9, and 10, 1957, under the title, "The Aid of Photogrammetry and Electronic Surveys in the Exploration of Canada's North."

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In California . . .

North Tejon shaping up as major high gravity field

Drilling is still on the increase, with five rigs now working and more expected shortly

By William H. LeRoy, Exploration Geologist
John P. Lavery, Jr., Geologist-Engineer
Reserve Oil and Gas Co., Bakersfield, Calif.

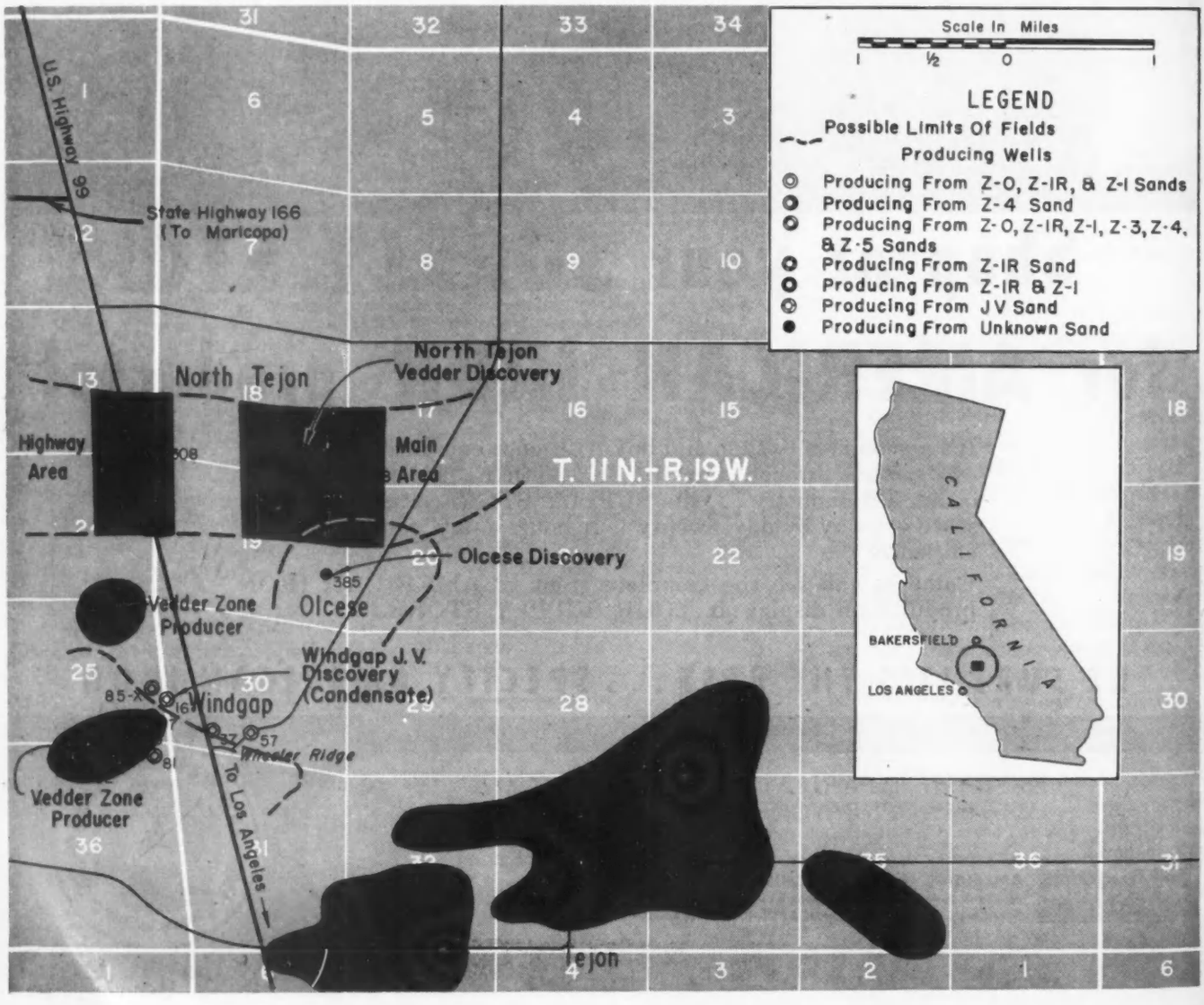
ONE OF THE most active areas in California today is the North Tejon field in the southeastern part of the San Joaquin Valley. Located about 25 miles south of Bakersfield, in Kern County, the area in recent months has been showing increasing promise of becoming a significant addition to the state's high gravity crude reserves.

Drilling still is on the increase, with five rigs now working and an additional two to three expected to move in within the next two months. Ten wells have been completed so far and the limits of the field have yet to be defined.

The new play centers in an area about 1 to 4 miles north and west of the Tejon field area which, for years, has produced from seven different horizons, ranging from the Chanac of Upper Miocene to the JV sand of Lower Miocene.

Area pay zones. The general North Tejon area pay zones are found at depths ranging from 9,500 feet to be-

Well Locations of Kern County's North Tejon Field



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Successful completions are closing gap between

tween 12,000 feet and 13,000 feet. At present, it can be divided into roughly two areas: The Main Area, site of the original deep Vedder zone discovery in March, 1957, by Reserve Oil and Gas Company with Butler-Wehr Associates; and the Highway Area, a westerly extension less than a mile from the Main Area, discovered in April, 1958, by Richfield Oil Corp.

Indications at present point to a probable joining of the Main and Highway sectors inasmuch as successful completions continue to close the gap between them.

Standard Oil Company of California in 1957 acquired a 50 percent working interest from Reserve Oil and Gas Company and its associates in approximately 2,000 acres in the North Tejon area.

The structure of the North Tejon field is interpreted as an easterly plunging nose, complicated by faulting. The faulting controls accumulation only to a minor degree. The main controlling factor appears to be an updip permeability barrier. Regional sub-surface geologic studies indicated a structural high in the area and subsequent seismic work substantiated this theory.

Production in the Main and Highway Areas is from the Vedder sands of Lower Miocene (Zemorrian) Age. These sands are found at depths ranging from 8,800 feet in the Highway sector to as much as 12,000 feet in the Main sector. Average thickness of the producing interval (gross thickness) is between 400 and 500 feet.

Depending upon the structural position of a well, depth and productive interval may vary considerably from location to location. A given well may produce from one to as high as six identifiable zones within the over-all Vedder sand section. Although the Vedder section is almost entirely sand, there are some silty—and tight—streaks in it. In general, the Vedder formation is a mendium to fine grained, sub-rounded sand, with some sections containing pebbles.

New pool discovery. Since initial discovery of Vedder production in the Main Area, production in the North Tejon area from that zone has been brought up to approximately 3,300 barrels per day of 35 gravity crude. The wells, all of them flowing, are beaned back to an average 14/64-inch choke.

About two months ago, a new pool discovery was made by Reserve in association with Tejon Ranch Company and Sunray Mid-Continent Oil Company in a southerly step-out from the Main Area of about one-half mile. This new pool discovery found saturation in the Olcese sand of Lower Middle Miocene Age. Top of this zone was encountered at 7,300 feet. Gross thickness of the zone is 150 feet. Although so far only a one-well pool, this Olcese discovery soon is to be evaluated, with additional development work scheduled to get under way sometime in September of this year.

Spacing pattern in the Main Area, where average well depth is about 12,000 feet, currently is 40 acres per well. In the Highway Area, where well depths average about 9,500 feet, spacing is on a 20-acre basis.

The Windgap Area, slightly over a mile south of the Highway Area, is a JV sand discovery (although some marginal Vedder sand production also has been found on its southwest flank) made by Richfield Oil Corporation in April, 1957. The Windgap structure, not related to the North Tejon structure, actually is an easterly extension of the Wheeler Ridge structure to the northwest.

Of the eight wells so far drilled and completed in Windgap Area, five are producing from the JV Sand at around 8,500 feet, and three wells produce from the Vedder, the latter pay section being very tight, with wells of a marginal nature. Of the five JV wells, four are producing 58 gravity condensate and one, on the southwest flank, is a black oil (37 gravity) producer. The JV producing interval is approximately 50 feet thick and wells in this section currently produce about 120 barrels per day each. At present, one rig is operating in the Windgap Area.

Significantly, the entire area, encompassing perhaps six to eight sections, has excellent prospects for future exploratory and development work. The fact that none of the several present pools has been defined yet, coupled with the very thick pay sections and multiplicity of sands, points to a gradually increasing tempo of drilling for some time to come.

Typical completion program. Typical of recent completions in the North Tejon sector is Reserve Oil and Gas Company's W-T 308-18, located in the Highway sector. It was completed in the Vedder sand from an interval 9,900 feet to 10,365 feet, with an interval of 465 feet of zone open to production.

After being produced at higher but ungaged rates, the well was cut back to a 20/64-inch bean and gaged at a 2,700 barrels per day rate, with a 630 cubic feet of gas per barrel ratio. Tubing pressure at this rate was 2,075 psi. The well later was reduced to a 10/64-inch bean, producing 385 barrels per day with a ratio of 1024 cubic feet of gas per barrel. Tubing pressure was 2220 pounds per square inch. The crude is clean and of 34 to 35 gravity.

On an average, the North Tejon wells are held down to about 350 barrels per day. Typical flowing pressures range up to around 1,000 psi. Average gas-oil ratio is in the order of 1,300 cubic feet per barrel.

Typical surface pipe program for the Vedder zone wells consists of drilling 17½-inch hole to about 1,350 feet and cementing 11¾-inch casing, circulating cement to the surface. For Olcese and JV zone wells, pipe is cemented at depths of from 750 to 1,000 feet.

For the production string, 10⅝-inch hole is drilled to the base of the basalt at about 11,700 feet, and 9⅞-inch hole below that point. For hole reduction and testing, 8½-inch hole is drilled. The production string usually is 7-inch, 23 to 29 pound N-80 and P-110, down to the top of the productive zone, with 5½-inch flush joint liner being run through the zone. Typical liner perforation program is eight rows of 2-inch, 100-mesh slots on 6-inch centers.

The production string cementing program usually consists of circulating to the surface a 1-1 mix of lightweights and deep well cement, mixed to an average of 90 pounds per cubic

North Tejon's Main and Highway sectors

foot. From 100 to 200 sacks of neat cement always are put around the shoe.

The reasons for single stage cement jobs are (1) protection of water sands in the interval 1,000 to 2,500 feet; (2) protection of casing from the caving basalt section at 10,000 feet to 12,000 feet; and (3) the hazards involved in multiple staging in deep, expensive wells.

Drilling program. Typical drill collar program consists of carrying 250 feet of 8-inch collars down to the basalt; 200 feet of 7-inch collars through the basalt and as far as 9⅞-inch hole is drilled; 175 feet of 6-inch collars in 8½-inch or smaller hole; and 200 feet of 4½-inch collars while diamond coring through the zone.

From 110 to 150 bits are used in each well; jet type being used to around 7,000 or 8,000 feet, and conventional rock bits from there on down.

The drilling mud program on a typical well is approximately as follows:

Surface to 6,500 feet	68-80 lbs/cu.ft.	45-60-sec.vis.	7-8 cc water loss
6,500-8,500	72-80 "	45-60 "	6-7 "
8,500-Basalt	76-80 "	45-60 "	4-5 "
Basalt-T.D.	90-92 "	80-90 "	3-4 "

Usually, drilling fluid is emulsified with oil below 8,500 feet, using crude oil on development wells and white diesel oil in step-outs or exploratory wells.

Drilling Problems. One of the serious problems encountered in drilling wells in this area involves the thick volcanic section found between about 10,400 and 11,700 feet (in Main Area), and at shallower depths elsewhere. The heterogeneous lithology of basalt and other volcanic materials, plus the fact that portions of the section are of an unconsolidated nature and contain streaks of bentonite, results in swelling of the hole and sloughing. The section is from 1,200 to 1,500 feet thick in the Main Area and from 0 to 400 feet in the Highway Area. Penetration rates in the basalt average about eight feet per hour, with footage averaging about 100 feet per bit. Although sticking of the pipe still is a potential hazard in the volcanic section, careful control of the drilling mud while drilling through it has reduced the danger considerably.

No lost circulation or blow-out problems have occurred and few crooked hole difficulties have been encountered. Mud pump pressures usually range from 1,000 to 1,500 psi. Table speed averages about 100 revolutions per minute, and from 8,000 to 14,000 pounds of weight usually are carried on the bit.

A preventive maintenance practice adhered to by Reserve Oil and Gas Company, when the contractor's rig is on day rates, is the fluxing of drill collars weekly. This practice, the company confidently believes, already has saved several possible fishing jobs.

Completing a well usually involves running 2½-inch tubing with a 7-inch packer set a joint or so above the top of the liner, with 2-inch tubing tail to base of the perforated interval. Drilling fluid is displaced down the annulus and up the tubing with crude oil. The well usually comes in flowing at a high rate and, after the flow cleans up, production is turned to the tanks at a restricted rate.

Rigs used in the Main Area usually are of the 15,000-foot capacity class, with somewhat smaller ones used in the Highway or shallower sectors. Typical deep drilling rig is equipped with a 136-foot mast, powered with 1,300 horsepower gas engines when drilling near production (where gas is available for fuel), or diesel powered on wildcats. Mud pump size may range from a 7x16 to 8x20 and is used for both drilling and mud-mixing.

About two days are required to rig up and spud in, and two days to tear down and move out. Ample drilling water having less than 100 g/g salinity is available. Nearest oil field supply center is Bakersfield. Most of the crews live in that city.

ACKNOWLEDGMENT

The authors wish to acknowledge with thanks the assistance given them by Robert P. Mangold, manager, Field Operations, and other members of the Reserve Oil and Gas Company staff, in the preparation of this article.

Radio Control Developments

Continued from Page 206

15,000 hour range. Standby equipment is provided with automatic switchover. Space diversity equipment was considered unnecessary because of the relatively short path length. However, this may prove useful as the system is expanded to the more distant platforms.

To study this need, continuous recording of the path signal level is provided. When coordinated with weather information, this record of "fades" and outages will provide a valuable guide in equipment selection for future installation. As a precaution against corrosion, humidity and heat, the RF equipment, multiplexing and supervisory tone equipment were installed on both platforms in insulated, air conditioned metal buildings.

As previously noted, this is an initial installation intended to encompass the entire Rollover field area. For this reason, exhaustive studies are being made of the equipment performance under offshore operating conditions. Also, future requirements for expansion have remained as part of the design requirements throughout the program.

It is believed this program has contributed to the development of a practical and economical solution to two problems which confront the engineer in his design of offshore telemetering and supervisory control systems—automatic starting, synchronizing and switching of engine driven generators and providing and maintaining precise power supply frequency control considerably within telemetering transmitter and receiver tolerance even though power is supplied by two independently operated engine driven generators.

It also is believed that this program is a practical means by which ever-rising offshore costs may be reduced. As previously noted, the experience gained will be used on future installations to reduce unit costs, improve equipment and simplify procedure.

ACKNOWLEDGMENT

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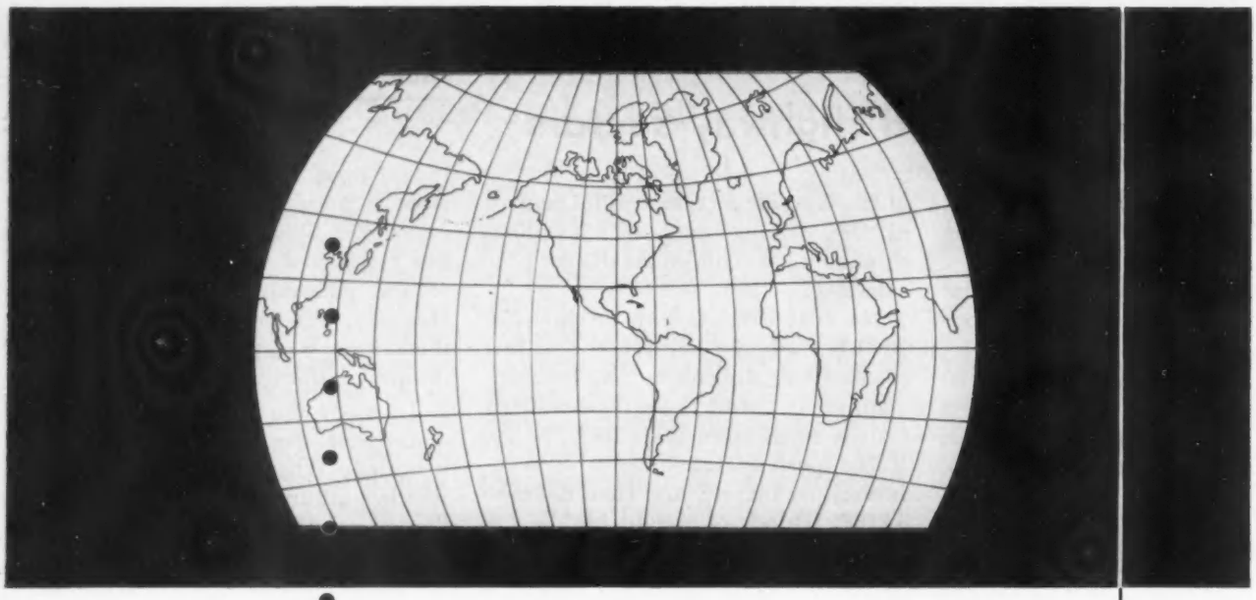

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QUICK LOK CONNECTIONS

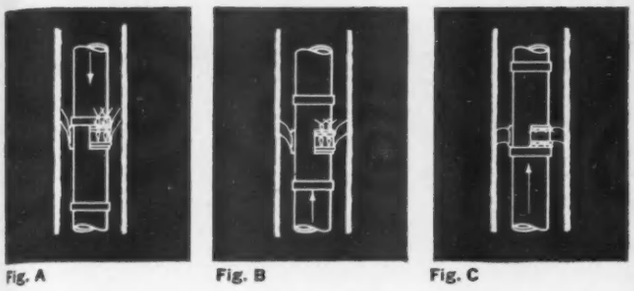

Fig. A Fig. B Fig. C

Fig. A Scratcher wires, retained by integral hinged mounting, swing freely upward and do not remove mud cake while running in.

Fig. B Even when casing is lifted out of the slips, the entire Scratcher remains stationary. Only when reciprocated, and

Fig. C ...only at the cementing area does the "scissors" action of the crossed wires remove mud cake.

Baker Scratchers remove mud cake only from the cementing area; this "controlled scratching" protects productivity.

While running in, the scratcher wires automatically swing upward along the casing, where they are safe from damage; permit free, unrestricted lowering of the casing; and do not disturb or remove mud cake. There is no danger of "balled-up" mud collecting on the scratcher wires to plug the annulus and contribute to pressure surges with possible "mudding-off" of the producing zone. Only when the cementing area is reached and the casing is reciprocated do the double rows of strong "crossed" spring wires automatically reach out, dig in, and remove the mud cake with efficient "scissors" action.

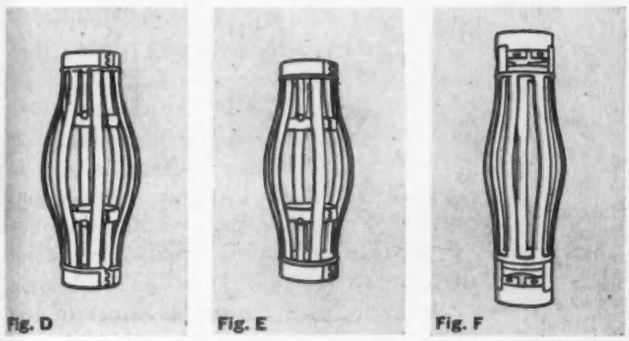

Fig. D Fig. E Fig. F

Fig. D "Extended" Range HINGE-LOK Baker H-25 Casing Centralizer. Product No. 9113.

Fig. E "Normal" Range HINGE-LOK Baker H-20 Casing Centralizer, Product No. 9112.

Fig. F "Slim Hole" SOLID-RING Baker G-15 Casing Centralizer, Product No. 910-G.

Baker Centralizers assure cementing clearance. "No-scrape" design prevents "balling", plugged annulus and stuck casing.

The QUALITY of Baker Casing Centralizers starts with "sled-runner" springs made of high quality spring steel—tested and pre-set by flattening in hydraulic presses—then butt-welded to collars to form a unit of great strength. Pre-setting of the springs to the pre-calculated optimum bowed height enables each centralizer to pass tight spots or dog legs without damage to the assembly, and ensures GREATER CENTERING FORCE for maintaining annular clearance for cementing.

Baker Centralizers do not remove mud cake which could plug the annulus, contribute to pressure surges and restrict productivity.

BAKER OIL TOOLS, INC.

Houston • Los Angeles • New York

Fig. G Fig. H

Fig. G Variable FILL-UP Valve as used in FLEXIFLOW Equipment.

Fig. H Variable FILL-UP Valve as used in DIFFERENTIAL Equipment.

Baker Fill-Up Equipment saves time in running casing, but does not create pressure surges that reduce productivity.

Destructive pressure surges—often created when casing equipped with conventional floating equipment is lowered into the well—can now be avoided. The Variable Valve in either Baker DIFFERENTIAL or Baker FLEXI-FLOW "Fill-up" Shoes and Collars, permits casing to fill from the bottom up; eliminates expensive, time-consuming surface filling; and automatically coordinates the *rate of fill* with the *rate of lowering* to AVOID high pressure surges. Baker FILL-UP Equipment permits the casing to be lowered at normal rates, saving rig time and reducing danger of sticking the pipe; chances for successful primary cementing are increased; formations are protected from high pressure surges which can impair their productivity.

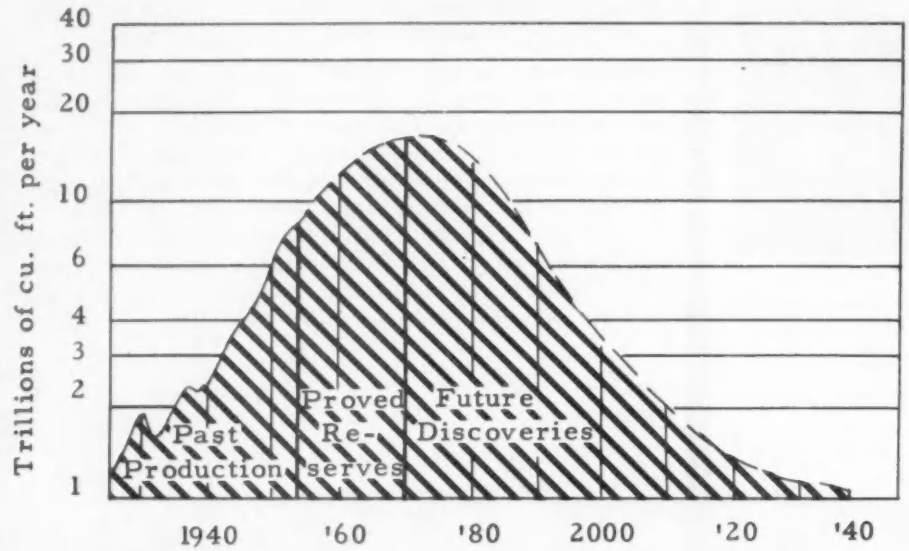

FIGURE 3—Possible pattern of natural gas production in the United States.

A new look at ultimate natural gas reserves

Revised estimates indicate U. S. natural gas reserves will outpace production for at least 40 years.

By Ralph L. Miller, Staff Geologist
U. S. Geological Survey, Washington, D. C.

THERE ARE many reasons to be optimistic over the outlook for natural gas reserves. But to discover and exploit much of the untapped supply of natural gas will require much geological work and insight, a host of technological skills and advances, and untold exploratory work and courage. These factors, perhaps more than any others, are the ones that really determine the size of ultimate reserves.

However, if ultimate reserves of petroleum in the U. S. hold true to recent estimates of 200-300 billion barrels, and if the undiscovered portion of this total will result in the discovery of at least 7,000 cubic feet of gas per barrel of oil, it is possible to arrive at a new and larger figure for ultimate natural gas reserves. Use first what seems the quite conservative figure of 200 billion barrels of oil for calculation.

Subtracting the past production and present proved reserves of oil totaling 88 billion barrels from estimated ultimate reserves of 200 billion barrels leaves 112 billion barrels of new oil yet to be discovered. The discovery and production of this amount of oil should result in the discovery of at least 7000 cubic feet of new gas per barrel of oil; 112 billion by 7000 equals 784 trillion cubic feet of gas yet to be discovered. To this must be added past production and present proved reserves as follows:

	Trillion Cubic Feet
Past production natural gas to January 1, 1957.....	137
Present proved reserves, January 1, 1957.....	232
Yet to be discovered.....	784
Ultimate reserves natural gas.	1,153

TABLE 1
Estimates of Ultimate Gas Reserves in the U. S.

Ultimate Oil Reserves (Billions of Barrels)	Gas/Oil Ratio (Cu. Ft. Per Barrel)	Ultimate Gas Reserves (Trillions of Cu. Ft.)
110 (Weeks 1947)	6,000	600 (Terry 1952)
200 (Schultz 1952)	7,000	1,150
300 ("Impact" 1956)	7,000	1,700

PART 2

If all of this unproduced gas were today in the category of proved reserves, this would amount to 110 years' supply at the current rate of consumption, but a lesser number of years based on the expected continued large increase in use.

If one accepts the more optimistic figure of 300 billion barrels as the ultimate reserves of petroleum in the U. S., and assumes that only 25 billion of this will be from improved secondary recovery operations that may be expected to have a low gas-oil ratio, he obtains by the same process of calculation a figure of about 1700 trillion cubic feet, which is nearly three times the 1950 estimate. Again, if the whereabouts of all this gas today were known, and if it could all be produced by presently known methods, it would amount to 165 years' supply at present rates of consumption. Table 1 summarizes these figures in tabular form.

This common mental gymnastic, dividing reserves by annual production to find the number of years a supply might last, is of course wholly misleading. Annual production tends to increase, which would require a smaller answer. On the other hand, operators will be discovering new gas fields long after the time when known reserves are on the decline. Likewise, it takes a long time to get all the gas out of a large reservoir. These last two factors alone will extend the time before the natural gas of the U. S. is exhausted.

These figures are manifestly not as precise as the arithmetic processes would suggest. Nevertheless, they do indicate the order of magnitude to which thinking should be adjusted. Although it is impossible to arrive at a definitive figure for any predictions, it can be said with some confidence that the ultimate gas reserves of the U. S. will one day be found to be at least as large as the lower figure of 1150 trillion cubic feet, and that the final answer is likely to be closer to

the upper figure of 1700 trillion cubic feet.

Gas Reserves Now More Important. The reason why awareness of the substantial gas reserves in the U. S. is coming to public attention at this late date is easily explained. To a certain extent, natural gas is an end product in the metamorphic cycle of the liquid hydrocarbons—just as anthracite and graphite are the end products of the metamorphic cycle in coal. Natural gas occurs alone independent of oil in belts of strongly folded rocks, and also the ratio of gas to oil increases with depth.

Only small amounts of gas were found in the early days of shallow exploration in the U. S. Most of that was flared for want of a suitable distribution system. Under the circumstances then existing there was little interest in gas reserves. With drilling now proceeding to increasingly greater depths, it is inevitable that gas will be found in increasing quantities.

Future Consumption. Now consider briefly the probable future rate of consumption of this gas. It seems obvious that use will increase to some kind of peak or plateau, then gradually taper off, somewhat as illustrated by the typical bell-shaped curve in Figure 3.

The nation is obviously still headed up the steep slope of the consumption curve, with capacity to meet the demand not yet strained. It is therefore impossible to project the curve with any professed accuracy. The accompanying curve was prepared in 1956 by Pogue and Hill on the assumption that the ultimate reserves of the U. S. would be 750 trillion cubic feet. If either prediction of 1150 or 1700 trillion cubic feet were to be substituted, the curve would obviously need expanding either upward or to the right, or both. The location and shape of the crest and of the decline slope are quite unpredictable. They depend on such obscure factors as the future rate of discovery, the actions of regulatory bodies, and the availability of alternative sources of energy. A scientific break-through that would permit widespread use of the energy of nuclear fusion could materially change the shape of the curve.

Considering that there is a finite limit to the quantity of gas we have inherited, a peak and a subsequent decline in production are inevitable. The data now available suggest that the peak will arrive later than the 1970 date shown by Pogue and Hill. But it seems unlikely that it can be delayed beyond 40 or 50 years.

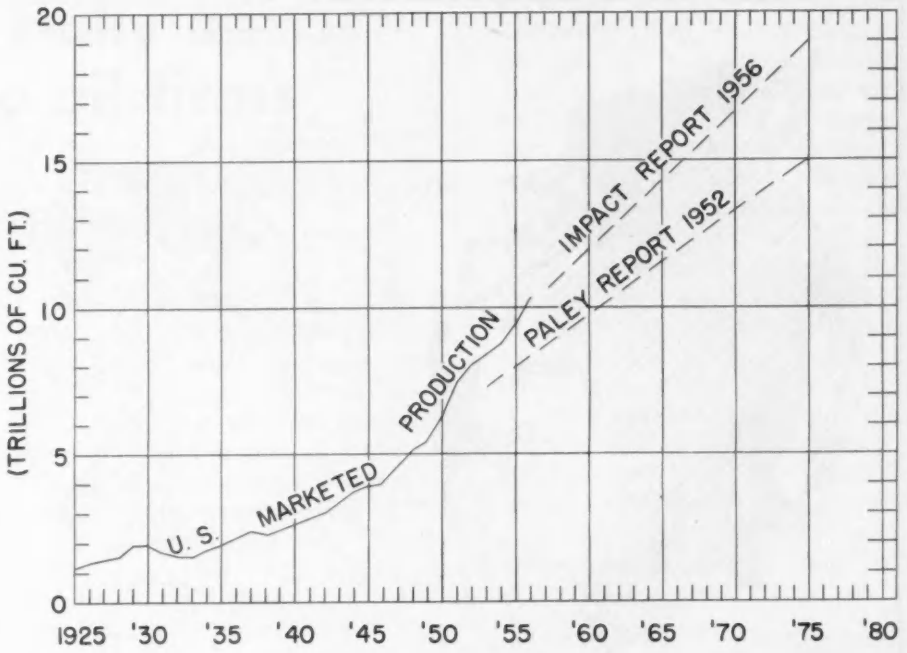

FIGURE 4—Past production and estimated future consumption of natural gas in the United States.

Gas Use Up Sharply. Figure 4 shows the dramatic increase in use of natural gas that has taken place between 1926 and 1956. During this 30-year period the consumption of natural gas has increased almost eightfold, from about 1.3 to 10 trillion cubic feet, and the trend is still headed steeply upward. Contributing to the increase has been 1. our burgeoning population, which has increased about 40 percent during the 30-year period; 2. our increased industrialization, which gained impetus during and after the Second World War; and 3. various social changes, which have resulted in an improved standard of living for a large number of people.

In recent years the rate of increase in use of natural gas in the U. S. has exceeded all expectations. Under such circumstances it is extremely difficult to predict what the future consumption of gas might be.

Shown in Figure 4 are two predictions of the future demand of natural gas, which call for vastly increased quantities. One of these estimates, made by the President's Materials Policy Commission in 1952 (the line marked "Paley Report"), predicted that the demand by 1975 would be of the order of 15 trillion cubic feet. In 1952 this seemed like a very substantial estimate. But the demand during the last few years indicates that the consumption by 1975 will be considerably more than 15 trillion cubic feet.

In 1956 The Panel on the Impact of the Peaceful Uses of Atomic Energy predicted that the demand by 1975 would be of the order of 19 trillion cubic feet. This prediction, which is shown by the line marked "Impact Report," seems now to be reasonable and possible of attainment. Recalling the history of past estimates, it would not be surprising if this estimate, like its predecessors, turns out to have been too conservative.

If the consumption of gas should increase at the rate shown by the uppermost line, the total amount consumed between Jan. 1, 1957, and Dec. 31, 1975, would be of the order of 280 trillion cubic feet. This seems like a very large amount, but it is only a little more than the present proved reserves of 231 trillion cubic feet. It is considerably less than the estimated undiscovered reserves which surely will be found in steadily increasing quantity during the next few years.

Sources of New Gas. Where is all this new gas coming from? The sketch map in Figure 5 shows in a general way areas in the U. S. that may be considered impossible, unfavorable and favorable for finding gas.

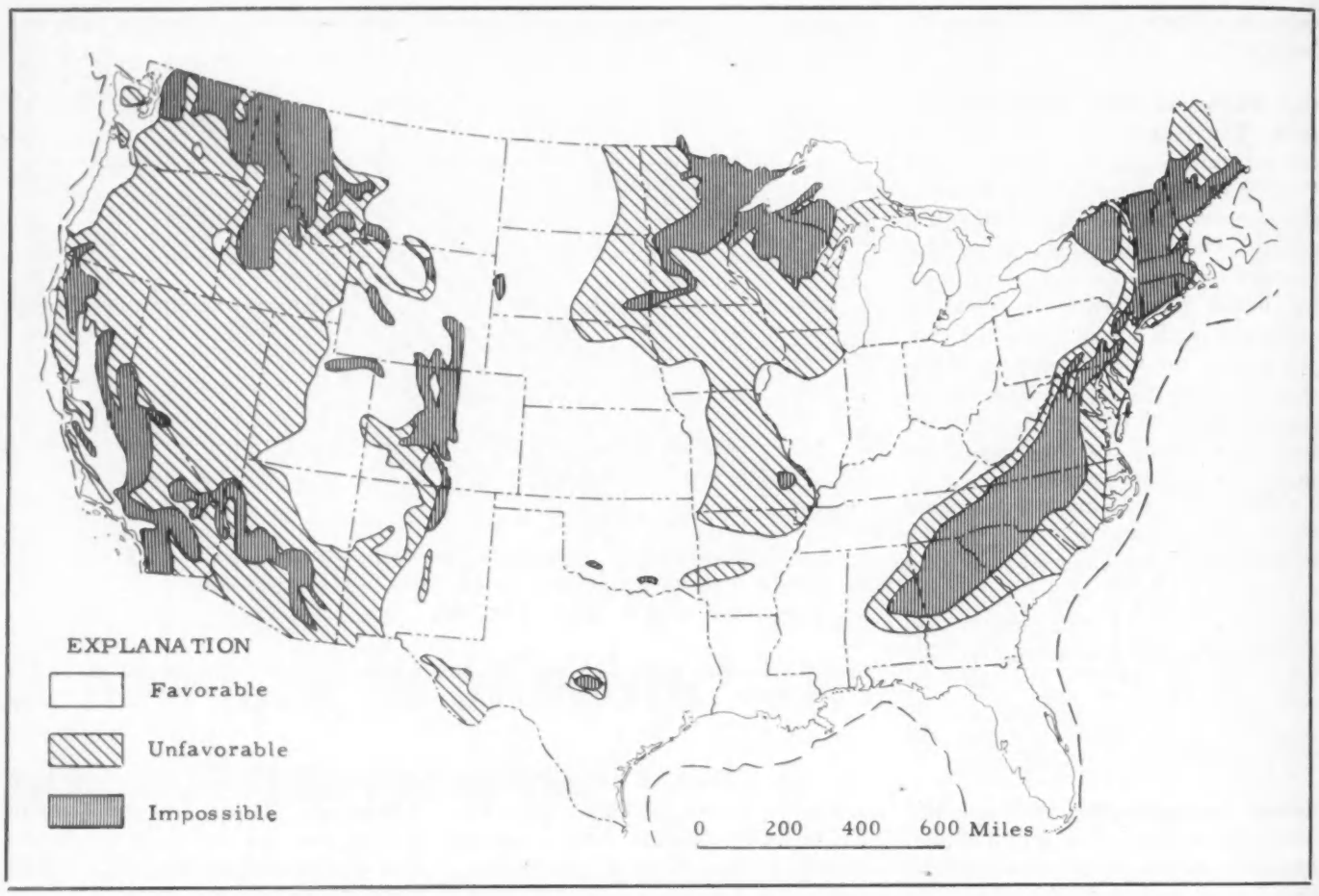

FIGURE 5—Likelihood of finding commercial amounts of oil or gas.

It is within the favorable area that industry is finding more than 1000 new oil and gas fields or pools a year. Many of these discoveries are in areas that have hitherto been explored only slightly. Others are at greater depths than had been previously explored. Most spectacular, of course, are the offshore wells in the Gulf of Mexico, where production has been obtained as far as 48 miles from land, and in water as much as 92 feet deep. Drilling has already extended even farther offshore and into deeper water, and designers are planning equipment for drilling in still deeper water. At this early stage of offshore exploration the search has been chiefly for salt dome structures, which are easily detected by geophysical techniques, and which have a high probability of being productive. As exploration advances and subsurface geologic information accumulates, we can look forward to search for stratigraphic traps, facies changes and other less obvious traps, and there is no reason known why we may not hope to find one or more East Texas and Hugoton fields. Although the search for oil and gas on the Atlantic Coastal Plain has been unsuccessful, further search will continue there and may be extended onto the Atlantic Continental Shelf.

Natural Gas Imports. Thus far in this analysis, consideration has been given only to domestic gas reserves. We must not overlook, however, the possibility of large-scale imports of gas from other countries. Pipe lines are already being built to bring both Canadian and Mexican gas into the U. S.

Much more significant, perhaps, is the possibility of importing liquefied natural gas from the Middle East or other places where it is a drug on the market to places where pipe line gas is expensive or in short supply. Many problems remain to be solved in this unproven method of handling natural gas. But, human ingenuity being what it is, it will not be surprising if it becomes economically and technologically feasible to move large quantities of natural gas long distances over the seas.

ACKNOWLEDGMENT

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Argentina partially opens door to private oil firms

Government's oil agency contracts with U. S. and other companies for developing country's oil

ARGENTINA HOPES to increase crude oil production substantially and reduce dependence on imported oils as a result of contracts made recently with U. S., Belgian, West German, Argentine and other private firms.

In dealing with the companies, the government oil company, Yacimientos Petroliferos Fiscales (YPF), made some contracts of a straight service type. Others are venture type contracts, in which the private firms assume a large share of risks involved. None is a conventional concession. Any oil produced by any firm must be sold to YPF at fixed low prices, rather than on the open market.

The contracts represent a compromise between straight concessions to foreign firms, politically undesirable, and exclusive development rights for YPF, which have failed to meet Argentina's oil needs. Responsible elements of the Argentine press have approved the contracts.

The Argentine contracts may have international significance. They may serve as patterns for similar deals in other countries. Brazil, for example, was expected by some sources to follow Argentina's example and let foreign firms in on a contract basis to develop some of Brazil's oil resources, especially since the press there has been generally in favor of breaking the monopoly of "Petrobras."

In Argentina, YPF has renewed its agreements with Chubut, Santa Cruz, and Mendoza provinces, as required since the nation has reverted to the 1853 constitution, which places ownership of oil in the provincial government. YPF still had to come to terms with Salta, but it was thought that agreement would be reached in the near future. The new contracts are not subject to Congressional ratification. Hence there is little likelihood of their becoming a political football.

Following are summaries of the provisions of some of the contracts recently concluded or being negotiated.

Pan American International Oil Company. This firm agreement covers development and operation of certain areas of YPF reserves in Patagonia and southern Argentina. It covers three structures in the provinces of Chubut and Santa Cruz, Anticlinal Grande known as Sarmiento, Cerro Dragon and Canadon Grande, on which YPF already has production. Pan Am International is an affiliate of Standard Oil Company (Indiana).

The contract is for 15 years, with an option for an additional five years. It requires Pan Am International to develop these areas to the fullest extent and as rapidly as possible. Fifty wells will be drilled within the first year, 10 of these in the Sarmiento area and 40 in the Cerro Dragon area. Five rigs will be employed.

Depending on results of the first year's program, Pan Am International will drill an additional 100 wells within the second year, and build a pipe line. Twenty of the additional wells would be drilled in Sarmiento and 80 at Cerro Dragon. Ten rigs would be used during the second year.

The pipe line would be about 40 miles in length from Cerro Dragon to the coast in the Gulf of San Jorge. An additional 20 mile extension from Cerro Dragon to Sarmiento will also be considered, depending on results of operations.

Pan American International will assume the entire risk in the undertaking, and will provide the funds for all drilling, development, and construction.

The contract involved no stipulation for expenditure of a fixed amount of money. Work commitments have been made as a minimum program. Total expenditures will be governed by the extent and cost of operating the areas.

For developing the YPF reserves, Pan Am International will receive as payment $1.60 per barrel, after payment of all Argentine taxes incurred by it and its contractors, for all oil delivered to YPF storage facilites in the port of Comodoro Rivadavia. Sixty percent of the price, or 96 cents, will be paid in U. S. currency and the balance in pesos. The arrangement will represent a saving to YPF of about two thirds on the dollar cost of imported oil today.

Pan American International hopes to be able to attain a rate of delivery to YPF of about 30,000 barrels a day within 24 months. That would represent about a one third increase in current Argentine production, which at the end of 1957 was estimated at 90,000 barrels daily. The balance of the country's requirements, currently estimated at about 255,000 barrels daily, is made up of imports of crude oil and refined products.

Loeb Rhoades and Company. This firm is a New York investment banking house, not an oil company, although John Loeb, one of the partners, has drilled some wildcats in Louisiana on his own initiative. Loeb Rhoades was negotiating a venture-type contract with YPF late in the summer, and it was expected to be finalized shortly. The areas had not yet been disclosed.

Loeb Rhoades expected to invest at least $100 million. This amount was to be repaid by YPF out of 50 percent of the foreign exchange accruing to YPF by replacement of imported oil by production that may be achieved pursuant to this contract.

YPF's payments are to begin 12 months after commencement of crude oil production, commencing at the rate of 25 percent of such foreign exchange savings, increasing to 50 percent the third year of production, until all sums so invested are repaid. Profits allowed Loeb Rhoades are on a sliding scale, between 15 and 20 percent of exchange saved during 20 years. YPF can buy out Loeb Rhoades at any stage of the operation.

Lane-Wells Company. Lane-Wells negotiated a straight service contract for repair and maintenance of YPF's wells. The three-year contract, reported as firm, obligated Lane-Wells to invest initially $2.5 million. This may be increased to $10 million. Lane-Wells was to be paid in Argentine pesos. But YPF was obligated to acquire enough dollars to take care of essential dollar payments that

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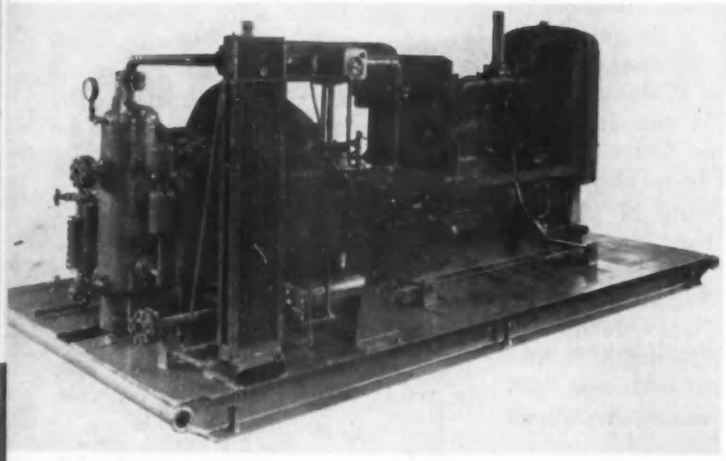

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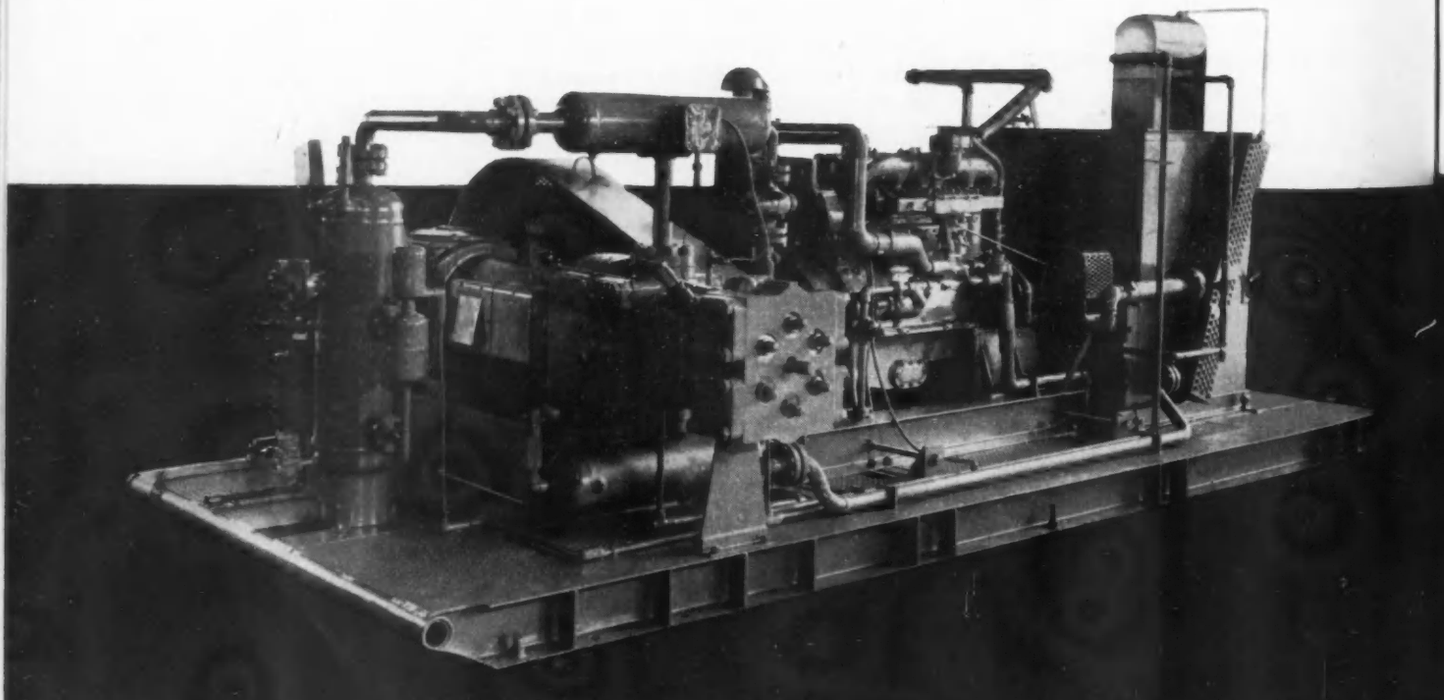

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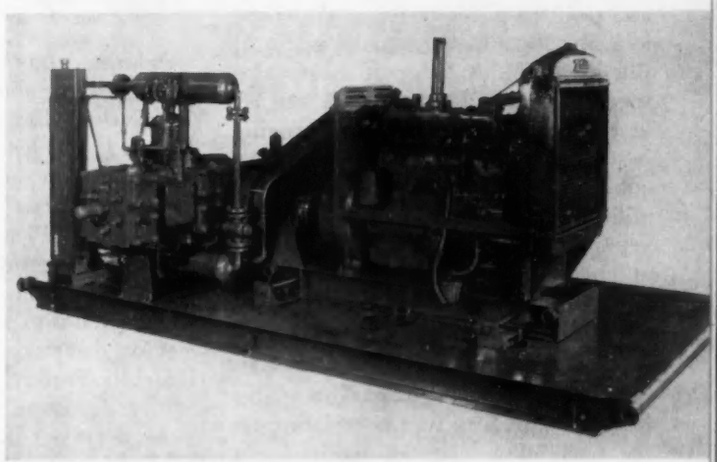

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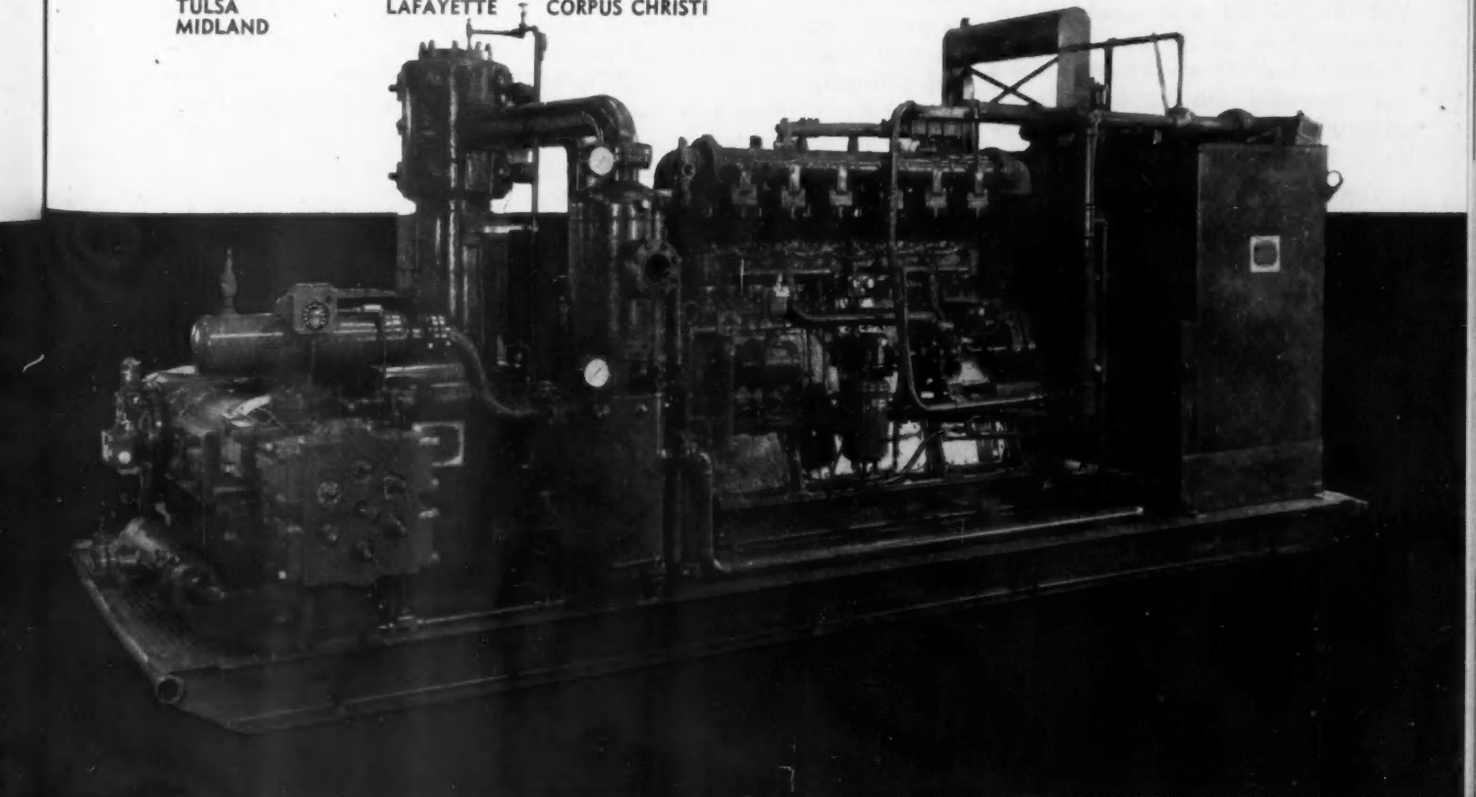


Lane-Wells must make to carry out its work under the contract.

Other contracts were being negotiated, and are described below.

Atlas Corporation, Hidden Splendor Mining Company, Petro-Atlas Inc., Williams Brothers Corporation, and Ferrostaal A. G. This group was negotiating a straight contract with YPF, envisioned in a letter of intent to provide for drilling up to 4,000 wells in the Comodoro Rivadavia area during a six-year period. The deal was expected to involve $240 million to drill the holes and an additional equal amount to equip them.

Atlas Corporation and Williams Brothers. In August, 1958, Williams Brothers was to investigate the feasibility of building a $130 million, large-diameter gas line from Plaza Huincul to Buenos Aires and a similar line from Comodoro Rivadavia to Buenos Aires. The two lines would approach Buenos Aires from the west and south respectively, and would join in a common system south of Buenos Aires. A letter of intent also specifies that this group will sell oil and its derivatives to YPF, ranging in quantity from 2.8 to 5.6 million cubic meters (17.6 million to 35.2 million barrels) from two to three years after the contract is finalized, at current market prices. YPF may pay 20 percent in cash, and the balance in four equal semi-annual payments at 4.75 percent annual interest.

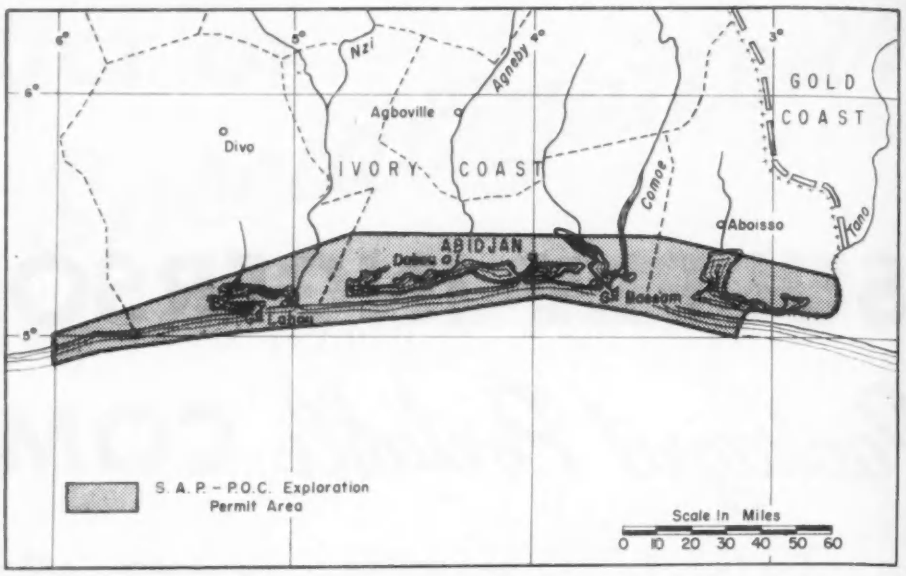
Sea Drilling Corporation. This New Orleans firm was negotiating on the basis of a letter of intent for a venture-type contract. Payments by YPF for oil delivered would be on the same basis as the Pan-American contract described previously. Sea Drilling would complete a number of wells offshore from Comodoro Rivadavia.

Compañía Astra de Petroleos. Astra is an Argentine firm that has operated limited concession areas for a number of years. It has some spare rigs, and was negotiating a straight 12-month, $1¼ million drilling contract with YPF.

Petrofina. President Wolters of Petrofina, the Belgian firm, was in Argentina negotiating with YPF on the basis of a letter of intent. A venture-type contract was expected to ensue, involving an area in which Petrofina would invest $35 million in drilling for and production of crude oil, which would be sold to YPF at a stipulated price.

Other companies. Conorada Petroleum Corporation and Pure Oil Company were also reported negotiating with YPF. No negotiations were reported between YPF with either the Royal Dutch Shell group (whose Argentine affiliate, Diadema, produces about 10 percent of Argentina's crude output) or Jersey Standard, which also has a crude-producing affiliate in Argentina.

—The End



Deep test site is east of Abidjan in east central portion of permit area shown here.

Deep Test Due for Africa's Ivory Coast

A large rotary rig was scheduled to begin drilling about September 15 in the Ivory Coast of French West Africa. It was located east of the town of Abidjan, in the east central part of the permit area of Societe Africaine des Petroles, Plymouth Oil Company, Benedum-Trees Oil Company, and M. L. Benedum.

The well is expected to go to 13,000 feet or deeper. The rig, owned by Laughlin-Porter Drilling Company of Midland, Texas, is capable of going to even greater depths.

In the 2.4 million acre concession the French company has a 51 percent working interest and will be the operator, at least through 1958. Plymouth Oil Company has a 39 percent interest, and the other two participants hold 5 percent each.

The exploration permit of 3,720 square miles covers the whole of the Ivory Coast Tertiary-Mesozoic Basin. The land part of the basin appears to be a narrow trough, limited to the north by a large fault.

During 1957 a marine reflection seismograph survey was conducted in the offshore part of the permit. A land geophysical crew started operations during the latter part of 1957 and is continuing to work in the area. Seven shallow geological core holes have been drilled across the area.

In the eastern part of the basin there exist surface oil seeps, and oil and gas shows have been encountered in shallow wells. It is expected that Lower Cretaceous and Jurassic will be present in the deeper part of the basin.

Tennessee Gas Has Large Concession in Ecuador

Tennessee Gas Transmission Company has acquired an oil and gas concession of nearly 1½ million acres in west central Ecuador. It is in the Daule Basin, about 20 miles north of Guayaquil, Ecuador's largest city and chief seaport.

A subsidiary, Tennessee del Ecuador, S. A., will start operations on the concession about June 1, 1959, at the beginning of Ecuador's dry season.

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Extension of Pipe Line In Israel Is Now in Use

The last link of the Elath-Haifa crude oil pipe line system between the Gulf of Aqaba and the Haifa Refinery has been completed. The system includes an 8-inch line from Elath to Beersheba, completed early in 1957. Later a larger diameter line from Beersheba to Ashdod Yam on the Mediterranean was built. Now Ashdod Yam has been connected with Haifa through another extension, consisting of pipe 16 inches in diameter.

Israel is still trying to interest international oil circles in using a proposed 32-inch crude line from Elath direct to Haifa to bypass the Suez Canal.

Venezuela Will Have Fewer Well Completions in 1958

A total of 1,400 completions are expected in Venezuela during 1958, though total could rise to 1,500 or drop to 1,200 depending on intangible factors during the second half of this year. First quarter 1958 well completions amounted to 327, representing a slow start. This year's completions are bound to drop below the 1,746 wells completed in 1957.

Iraq's Kirkuk Field to Have Water Input Plan

Iraq Petroleum Company has designed a water injection program to maintain reservoir pressure in the huge Kirkuk oil field, Iraq. Water will be taken from the Zab River at Dibis and injected under pressure in Kirkuk pay horizons below the oil-water contact.

Argentina's YPF Plans to Run 100 Rigs by Year End

In Argentina Yacimientos Petroliferos Fiscales (YPF) had about 70 rigs operating as of midyear 1958 and hoped to have 100 in operation by the end of the year. In addition, YPF planned to have three contract rigs working in Tierra del Fuego by September, 1958, on advent of more favorable spring weather. YPF had discovered two oil and two gas fields on its side of Tierra del Fuego as of midyear 1958, to depths of about 6,000 feet. A number of other structures have been indicated in this region by exploratory work.

Important oil discoveries were made during 1957 and 1958 in Mendoza, Plaza Huincal and Comodoro Rivadavia areas.

A total of 60,000 tons of 22 and 24-inch welded line pipe was being shipped to Argentina from three U. S. manufacturers for use in construction of the Campo Duran-Buenos Aires gas pipe line in mid-1958. The line is slated for midyear 1960 completion.

Drilling Will Be Resumed On Alaska's Iniskin Unit

Alaska Consolidated Oil Company, New York and Anchorage, headed by John V. Zappa, president, has acquired from Havenstrite Oil Company, Los Angeles, the 51,000 acre site of the Iniskin Unit Operators, Inc. deep test well in Alaska. Drilling on the property will be resumed this fall.

Located on the west shore of Cook Inlet, opposite Kenai Peninsula, the Iniskin Unit well was the first deep test drilled in Alaska. Started in 1954, the Iniskin well has reached 9,745 feet, with over 3,000 feet of oil saturated section reported.

Along with the Iniskin site, Alaska Consolidated acquired one of the largest oil drilling rigs in North America. Built especially for the Iniskin Unit drilling, the rig can reach a depth of more than 20,000 feet. It is already in place at the drill site.

Coastal Drilling Company, Bakersfield, Calif., will conduct the drilling operations when work is continued this fall. The same company drilled the discovery well of Richfield Oil Company on Kenai Peninsula last year.

The Iniskin Unit was put together by Russell Havenstrite, late president of Havenstrite Oil Company, and a group of associates.

Iraq Plans to Use Natural Gas from Rumaila Oil Field

The Iraq Development Board is planning to utilize natural gas from Rumaila oil field for a power plant and a fertilizer factory in Basrah. Presumably such a program would entail a gas pipe line of about 30 miles.

Aramco Expected to Drill About 27 Wells This Year

Arabian American Oil Company is expected to maintain five active drilling rigs in Saudi Arabia during 1958, and to complete about 27 wells this year. The new mobile drilling platform was being outfitted at Ras Tanura upon arrival from the U. S., and was to be used to develop the new Manifa offshore oil field. In the meantime, the "Queen Mary" was being used to complete Safaniya 33 at midyear, before being moved back to Manifa.

At Khursaniyah, an east flank well was successfully completed as an oil producer. At Khurais, Well 3 was being completed as an oil producer in the Arab "D" member. This extension well is located about six miles southeast of the discovery made late in 1957. At 'Ain Dar, Well 58 has been completed at a location 6 miles north of 'Ain Dar 56, which in turn appears to be a 12-mile extension of the mammoth Ghawar field. 'Ain Dar 57 was completed as an oil well between 56 and the proven limits of Ghawar to the south. The new Fazran ('Ain Dar 56) area is thus an extensive producing locality, regardless of whether it extends Ghawar or is a separate field in itself.

The gas injection program for 'Ain Dar has been enlarged to include a total of eight injection wells. The water injection program at Abqaiq has also been enlarged by completion of a water pipe line from the Persian Gulf. The water is being treated to inhibit corrosion and bacterial action.

Seismic Work Done In British Guiana Waters

California Oil Company (British Guiana) Ltd. has been doing seismic exploration work in waters off the West Coast of British Guiana in South America. The company, a subsidiary of Standard Oil Company of California, was granted an exploration license on 16,000 square miles there.

Large Natural Gas Field Found in Southern Russia

Soviet sources announced discovery of a large natural gas field in Turkmen Republic, in southern Russia east of the Caspian Sea.

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Horne Well Service Co.....3-5396
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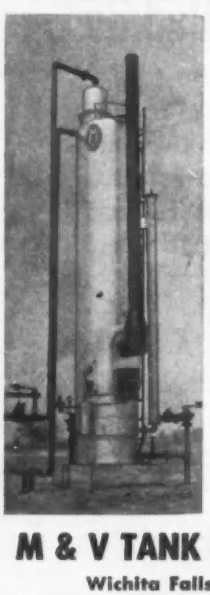

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What's Happening among MEN in the INDUSTRY

Carl A. Houy has been elected to the board of directors and named vice president, drilling and production, of **Vista Petroleum Corp.** Since 1955, Houy has been active in both domestic and foreign oil and gas exploration. He is also executive vice president of Bel-Air Oil Co., an independent producer in the Denver Basin.

Carl A. Houy

Ralph Z. Marsh and **Donald O. Hanson** have joined the Production Engineering division of **Gulf Research & Development Company** as research engineers. Marsh came to Houston from Denver.

Chas. F. Bedford

Charles F. Bedford has been elected vice president in charge of production and a director of **Pan American International Oil Co.**, a wholly owned subsidiary of Pan American Petroleum Corp. Bedford was formerly general superintendent, Producing department, for Pan American Petroleum in Tulsa.

A. O. Saterdal, formerly division geologist of Rocky Mountain division of **Wm. Ross Cabeen & Associates,** Denver, has been promoted to division manager. He replaces **Burdette A. Ogle** who recently was transferred to the Los Angeles headquarters of the firm as manager of exploration. In other promotions announced by the consulting firm, **Paul Westrup** of the Denver office was named division engineer of the Rocky Mountain division, replacing **Craig R. Norton** who was transferred to Los Angeles as chief engineer.

The Atlantic Refining Company has announced the appointment of **Ross E. Williams** as assistant to the vice president and general manager of domestic and foreign crude oil production.

J. P. Malott has been promoted to assistant general manager of **Continental Oil Company's** Rocky Mountain region, with headquarters at Denver. Formerly manager of Conoco's headquarters Production department at Houston, he will succeed **L. L. Aitken,** who recently resigned to become executive vice president of Utah Southern Oil Company. It was announced at the same time that **Wayne E. Glenn,** Denver, assistant Rocky Mountain region production manager for Conoco since 1952, has been promoted to manager of Conoco's headquarters production department at Houston, succeeding Malott.

Macmillan Petroleum Corporation announced the election of **Edward J. Barnes,** executive vice president, replacing **S. M. Batterson** who will remain as vice president to advise on banking and finances. At the same meeting **H. C. Akerberg,** vice president—lubricating oil sales, and **S. M. Thompson,** secretary and treasurer, were elected directors, and **J. B. Taylor** was elected assistant secretary-treasurer.

Jersey Production Research Company announced several reorganization changes in the Geophysical and Geological divisions of the company's Tulsa laboratory. The Geophysical division at the laboratory has been reorganized from two into four specialized sections. Heading up the two new sections will be **J. T. Baker** for geophysical technical services and **J. D. Skelton** for geophysical interpretation.

Hamilton Rogers, former president of Rowan Oil Company, has been elected a vice president of **Texas Pacific Coal and Oil Company.** Election of **A. H. Rowan,** board chairman of the Rowan company, to the T P board, was previously announced.

Continental Oil Company has established a new Production district, with headquarters in Artesia, N. M. Manager of the new district will be **W. A. Mead,** former production chief for Continental at Abilene, Texas. Other personnel who will help supervise production will be **D. L. Norwood,** district chief clerk and formerly a clerk in the Roswell division office, and **E. D. Coltharp,** district engineer, promoted from petroleum engineer, Bowie, Texas, district. **John M. Sprague,** vice president, The Carter Oil Company, has accepted an appointment as deputy assistant secretary of defense in Washington, D. C.

Langbourne M. Williams, chairman and president of Freeport Sulphur Company, has been elected a director of **The Texas Company.**

William P. Siard has been named district geologist for **Tidewater Oil Company's** Durango, Colo., district. He succeeds **Paul E. Carlton,** who recently transferred to the company's foreign department.

Norman J. Clark, formerly assistant manager in charge of Engineering and Consulting for **Core Laboratories, Incorporated,** has formed his own independent petroleum reservoir engineering and appraisal service. Prior to joining Core Labs,

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in 1955, he was for 14 years with Humble Oil & Refining Company, Houston, serving in various capacities including drilling and producing engineering assignments.

J. B. Storey and **Fred R. Schroeder** were elected vice presidents of **Union Producing Company.** At the same time announcement was made of the retirement of **W. J. Quigles,** senior vice president of the producing company and one of the real veterans of the oil and gas industry in the Gulf South.

L. H. Lukert, division geologist of Oklahoma division of **The Texas Company's** Domestic Producing department, is being transferred to Texaco's Research Laboratory at Bellaire, Texas, as research geologist. **C. S. Boyer,** assistant division geologist, Tulsa, will succeed Lukert as division geologist.

C. J. Christensen has been named division production superintendent for **Pan American Petroleum Corp.'s** Canadian division, with headquarters in Calgary.

R. F. Darrow has been promoted to assistant manager of production for **Continental Oil Company's** Rocky Mountain region, with headquarters in Denver. Formerly superintendent of production for Conoco's Kansas division, he succeeds **Wayne E. Glenn,** who recently was promoted to manager of the company's headquarters Production department at Houston.

John L. Bible

John L. Bible has announced his resignation as executive vice president and director of **Southern Geophysical Co.,** to organize his own company, Bible Geophysical Co. Inc., specializing in gravity and magnetic surveys and interpretations. Bible is president of the company which has headquarters offices in the Esperson Building, Houston.

The Aramco Overseas Company has announced the election of **Liston F. Hills** as a vice president. Hills succeeded **Ernest K. Schulze,** who is retiring after 38 years in the oil industry, as AOC's vice president and chief engineer.

Standard-Vacuum Oil Company has appointed **Robert E. Anderson** its general representative for Indonesia, succeeding **E. W. Berlin,** who is returning to company headquarters in White Plains, N. Y., for reassignment.

John D. Albright has been named assistant chief petroleum engineer for **Cities Service Oil Co.'s** Production division.

G. C. Richardson was elected a director of **Cities Service Oil Co. (Del.).**

International Brown Drilling Corporation announced that **Charles J. Bryce** is now affiliated with its company as manager of its Venezuela operations.

Yucca Mining and Petroleum, Inc., placed four new directors on its board of directors recently. They are **Sal J. Russo,** Chicago banker; **John F. Brady,** geologist; **Roland Schaefer,** Illinois steel executive; and **William W. Lynn, Jr.,** geologist.

Fred McCown is the newly appointed head of **T. T. Eason & Co.,** drilling division of Eason Oil Company. In his new capacity, McCown will be in charge of all drilling operations for Eason.

Four Corners Uranium Corporation announced that **Edward A. Koester,** formerly a consulting geologist of Wichita, Kansas, was elected to the board of directors and subsequently was vice president in charge of oil exploration of the corporation.

Stekoll Drilling Co. has opened engineering and operations offices at Estevan in Saskatchewan, Canada. **Charles Johnson,** an associate of the Stekoll company for almost 14 years, has been moved to Estevan from Texas as general superintendent for Canadian operations. Assistant superintendent is **Jack Zimmell** with Stekoll for 23 years, while **W. B. Woodall,** eight-year veteran Stekoll employe, will become manager of the Estevan office.

Tennessee Gas Transmission Company has organized a new exploration studies group. The new group will handle special geo-

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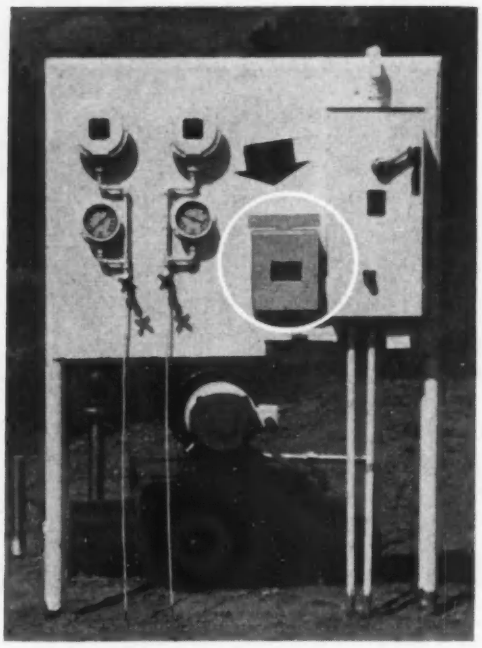

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logic studies for both the Domestic and Overseas Exploration departments of the company. It has been initially staffed by **Dr. H. J. Harrington,** who was named chief of exploration studies, and two senior geologists, **J. W. Keith** and **Dr. Morad Malek-Aslani.**

L. C. Ritts, Jr., has been appointed to the newly-created position of manager, explorations operations, for **Pan American Petroleum Corp.** Ritts will be located at the firm's general office in Tulsa. At Houston, Ritts is being succeeded as division exploration superintendent by **John C. Johnston,** who formerly held the same position in Pan Am's Rocky Mountain division at Casper, Wyo. **Leland C. Adams** replaces Johnston as division exploration superintendent at Casper. For the past three years, he has been district exploration superintendent at Lafayette, La.

J. H. R. Cromwell

James H. R. Cromwell, former United States minister to Canada, and **Robert K. Berry** were elected to the board of directors of **Seminole Oil & Gas Corporation.**

Kenneth R. Joynt assumed the duties of superintendent of **Magnolia Petroleum Company's** Gulf Coast Producing division. Formerly the assistant superintendent, Joynt will replace **J. B. Goodrich** who is retiring. **John S. Russell** will transfer to Houston from Oklahoma City and fill the assistant superintendent's job vacated by Joynt.

William D. Mounger was appointed petroleum engineer of the **Deposit Guaranty Bank and Trust Company** in Jackson, Miss. He will work with **W. M. Vaughey** in the newly-organized Petroleum department of the bank.

Glenn C. Sawvel has been promoted to superintendent of **Continental Oil Company's** Oklahoma City Production district. Formerly assistant district production superintendent in Oklahoma City, he succeeds **D. W. Matthews,** who has transferred to Wichita, Kan., as assistant division superintendent of Conoco's Kansas Production division.

W. Doyle Miller has been elected a director of **Seminole Oil & Gas Corporation.** At present Miller is an independent petroleum and management consultant in Dallas and Wichita, Kan., and president of Miller Petroleum Co.

J. A. Hall, Jr., district geophysicist for **Sinclair Oil & Gas Company** at Roswell, N. M., has been promoted to division geophysicist and transferred to Midland. He succeeds **John B. Etnyre,** who has accepted a position with another Sinclair company in North Africa.

Shelton-Warren Oil Company has added two new members to its board of directors. They are **J. B. Duval** and **Mansfield Tweedy.**

Kennis Witt Gilbert has been named district geophysicist of **Pan American Petroleum Corporation's** Lubbock district. Gilbert succeeds **J. D. Novotny,** who has been transferred to Pan American's Texas-Louisiana Gulf Coast division office in Houston in the capacity of division geophysical supervisor.

Phillips Petroleum Company made several shifts in production supervisory personnel. **J. N. Perkins,** Amarillo Production division superintendent, will become superintendent of the Western division at Midland, Texas. **W. M. Schul,** Denver division superintendent, has been named superintendent of the Central division at Oklahoma City. He will replace **M. L. Atkinson,** who has transferred to the International department and will be the company's representative in Jordan, where Phillips acquired an interest in oil and gas concessions last year. **F. W. Shelton,** Wichita division superintendent, will become special assistant to the manager of the Central Production area.

J. N. Biron has been appointed senior vice president and is being transferred to the London office of **International Drilling Company. B. G. Frazier** has been appointed vice president—engineering. He will be located in the Rome office in charge of the engineering staff. **O. D. Blankenship** will act as assistant to **Monty**

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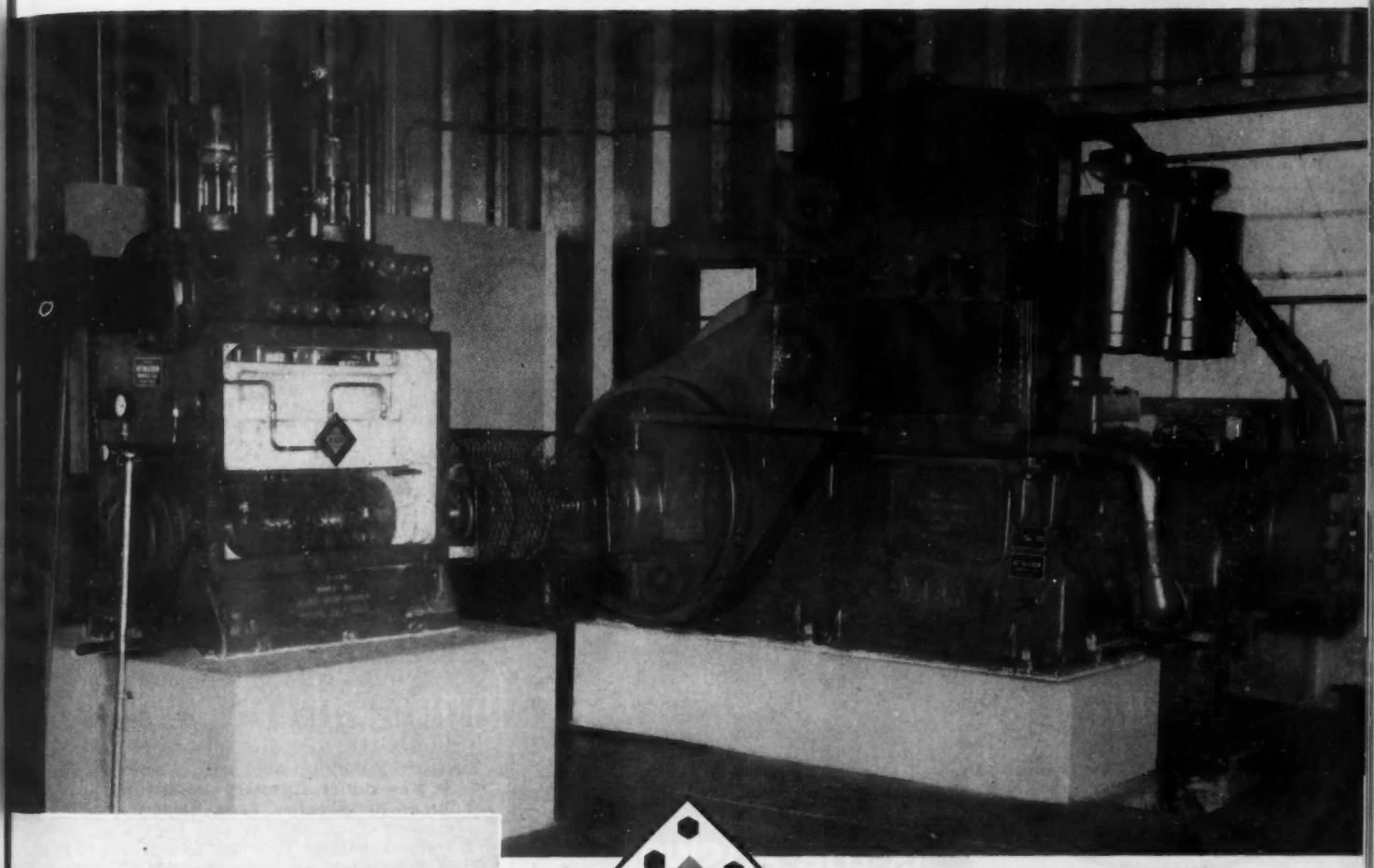

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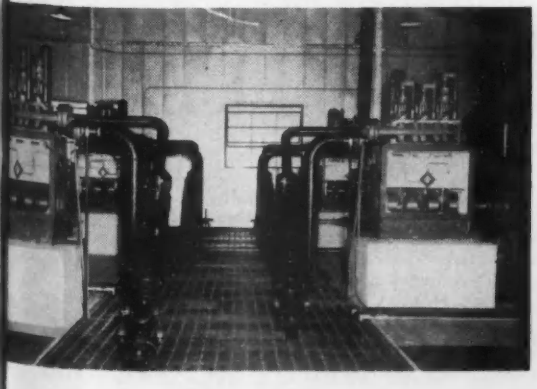

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R. Garrison, managing director, in handling operations. Blankenship will be located in the Rome office.

Dr. William C. Hayes, Jr., has been named assistant state geologist, replacing **Dr. G. A. Muilenburg** who is retiring after 10 years service with the Missouri Geological Survey.

Jack O. O'Brien was promoted to district exploration manager, Calgary district by **Tennessee Gas Transmission Company.**

John H. Ferry has been elected petroleum engineer of the **Denver National Bank.**

C. H. McClure, division exploration superintendent for **Sinclair Oil & Gas Company** in the Denver division, has been named assistant division manager of the Tulsa division. McClure succeeds **R. M. Kobdish,** who early this year was transferred to Sinclair's Houston division in a similar position.

Harold W. Sherrod has been transferred to Oklahoma City as district geologist by **Pan American Petroleum Corporation.** Prior to his transfer, he had been district geologist in Pan Am's Roswell, N. M., district office.

M. H. Dubrow has been promoted to the newly created position of assistant manager of **Continental Oil Company's** headquarters Production department. Formerly chief engineer in Conoco's Production department, he will continue to make his headquarters in Houston.

Iraq Petroleum Company and associated companies appointed **The Rt. Hon. The Viscount Monckton of Brenchley** to be chairman of the companies in succession to **Admiral of the Fleet Sir John Henry Dacres Cunningham,** who retired recently.

Pan American Petroleum Corporation's Rocky Mountain and Canadian divisions have made three personnel changes in its Producing department. **J. C. McCarthy** has been promoted to assistant division production superintendent, and **J. W. Phenicie** has been promoted to division engineer in the Rocky Mountain division.

Socony Mobil Oil Company, Inc., has made four changes in management positions. **Rawleigh Warner, Jr.,** manager of the Economics department, has been appointed Manager of the Department of Middle East Affairs. He succeeds **Arnold Stebinger,** who assumes a special assignment in connection with the company's overseas operations. **Thomas W. Phelps,** assistant to the chairman of the board of directors since 1949, becomes manager of the Economics department. **Paul Wollstadt,** who has been associated with the company since 1951, succeeds Phelps as assistant to the chairman of the board.

T. S. Scibienski announced his resignation as vice president of **La Gloria Oil and Gas Company** and the opening of his office as independent oil operator at Corpus Christi, Texas.

B. E. Groenewold, formerly president of Exploration Drilling and Oil Company, has been elected president of the **Midland Exploration Company** and as vice president of **Sharp Drilling Company.**

George Standard, drilling superintendent for **Harkins & Company** of Alice, Texas, retired recently. Replacing Standard will be **Ray Butler,** formerly production superintendent. He has been named superintendent of all drilling and producing operations. **Wilbur T. Steen,** tool pusher with Harkins and previous firms for 12 years, has been named assistant to Butler.

Tennessee Gas Transmission Company has announced changes involving three of its oil and Gas Exploration department personnel in Louisiana. **Philip Oxley,** formerly district geologist at New Orleans, has been promoted to district exploration manager at Lafayette. **Eugene E. McElvaney, Jr.,** has been named district exploration manager at New Orleans. He was formerly district landman in the New Orleans office. **John T. Velkas,** formerly senior geologist at Lafayette, has been transferred to New Orleans and promoted to district geologist, succeeding Oxley.

Continental Oil Company has established two production districts with headquarters at Artesia, N. M., and Pecos, Texas. Both districts will be units of Conoco's Southwestern region Production department, which is headquartered at Fort Worth. **W. A. Mead,** formerly district production superintendent for Conoco at Abilene, Texas, will be superintendent of the new Artesia Production district. He will be succeeded at Abilene by **R. C. Lannen,** formerly assistant district superintendent at Hobbs, N. M. **F. W. Gipson,** Odessa, Texas, has been promoted to superintend-

You'll win more than this prize. You'll increase drilling efficiency and control your mud better. Mud-O-Graf records every variation in mud weight, saving time and costly errors in the addition of weighting materials. All heavy and light streaks in the circulating system and their duration are recorded. Mud-O-Graf shows how often the hole is filled up when coming out of the hole and shows the time of a complete circulation. If it's a question of mud, ask for Mud-O-Graf.

WARREN AUTOMATIC TOOL CO.

Manufacturers of Pit-O-Graf and Rig Runner.

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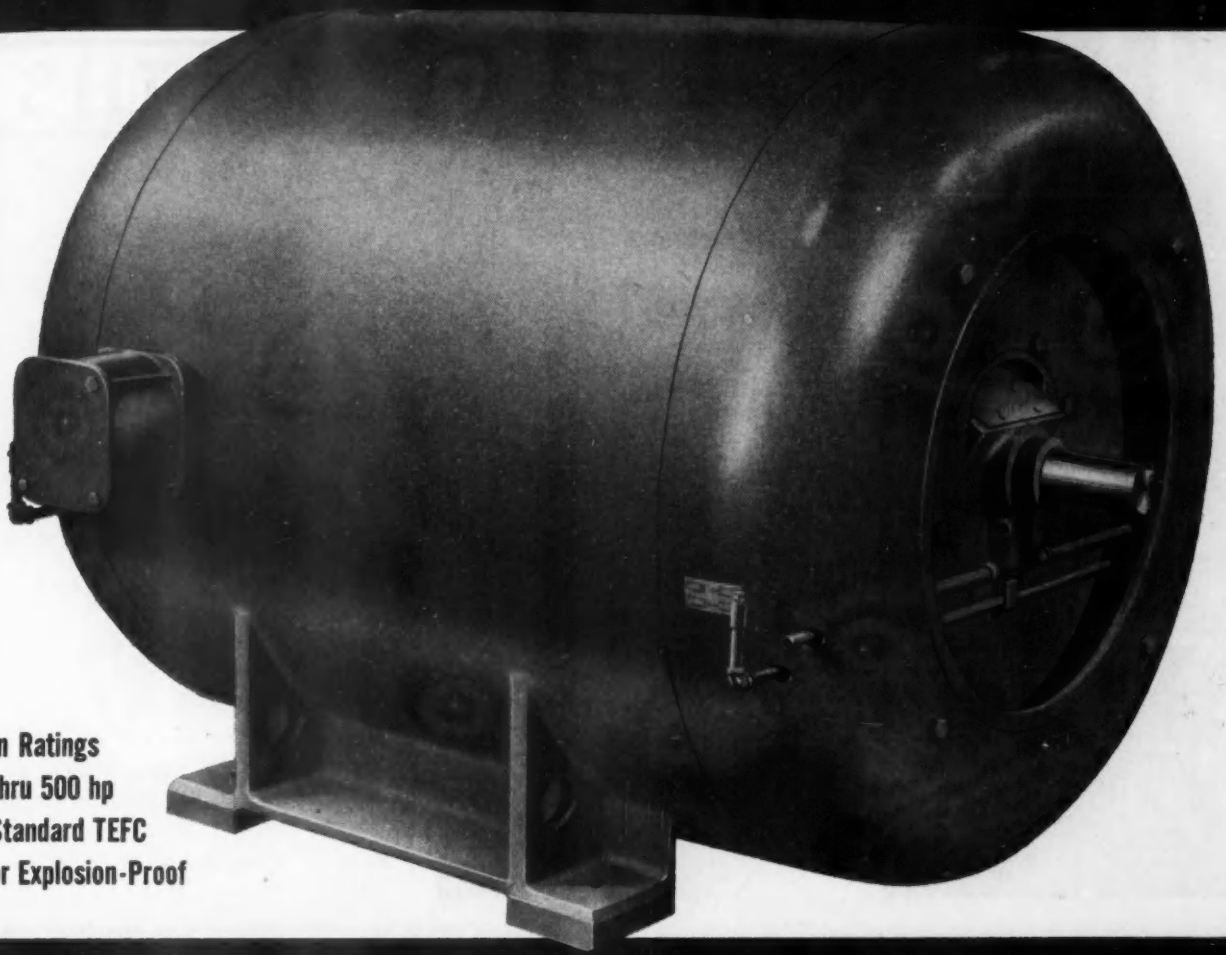
Lake Charles, La. HEmlock 6-2265 | New Iberia, La. EMerson 9-9862 | Harvey, La. FOrest 6-1441

Need COOLER RUNNING MOTORS for your big jobs?



In Ratings thru 500 hp Standard TEFC or Explosion-Proof

WAGNER Tube Ventilated Motors can solve your problem

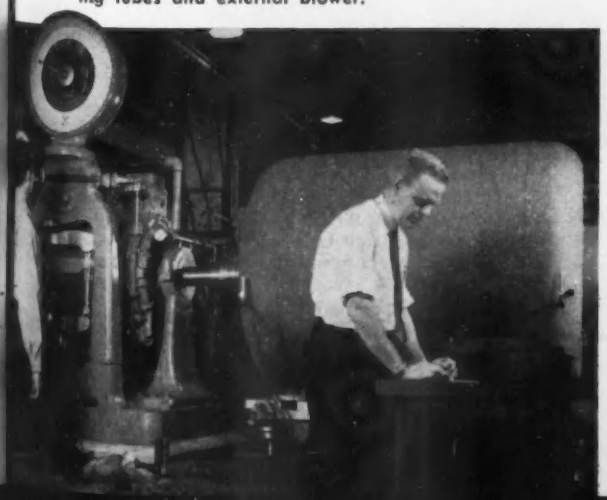
For big fans, blowers, pump drives—heavy duty applications where you need large motors with highly effective cooling systems for long life—choose Wagner Tube Ventilated Motors.

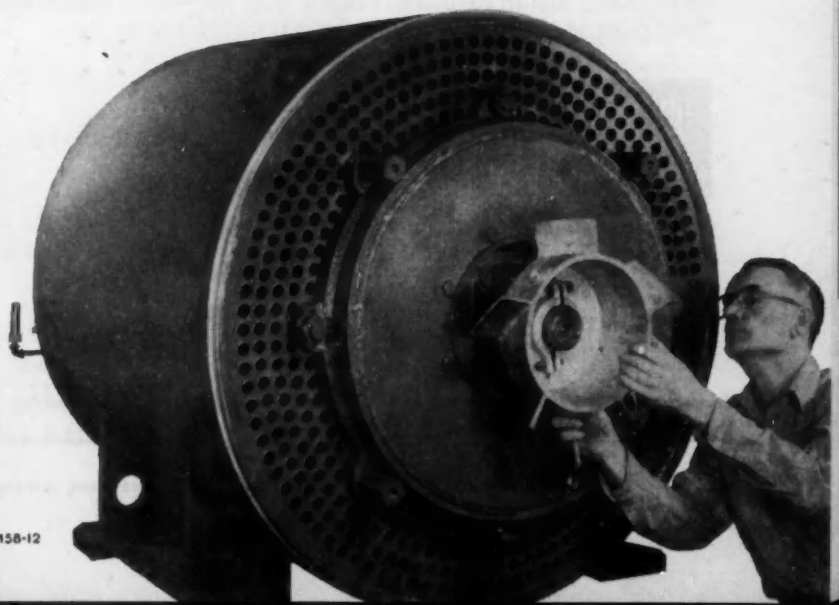
These motors have fabricated steel frames that are provided with a series of tubes through which cooling air is forced by an external blower. Internal blowers, one at each end of the rotor, circulate the warm air inside the motor through ducts in the rotor and stator and around the cooling tubes. This effective cooling system holds the operating temperature of the motor within the specified limits of 55° C Rise for Class A or 75° C for Class B insulated motors.

Wagner tube ventilated motors are available as Type YP, standard TEFC, with Class A or Class B insulation; or as Type ZP, explosion-proof, with Class A insulation only. Type ZP motors can be supplied with Underwriters' Labels for Class I, Group C or D, or for Class II, Group E, F or G locations. Let your Wagner Sales Engineer show you how these motors can solve your big motor problems.

WAGNER ELECTRIC CORPORATION • 6457 Plymouth Ave., St. Louis 14, Mo.

This 400 hp tube ventilated motor is being tested on a 1000 hp dynamometer at the Wagner plant. Photo of motor at right, with blower shield removed, shows cooling tubes and external blower.





WM58-12

"HEY! MIKE...

tell 'em up at the office we made schedule — bang on the nose! And Mike, do me a favour. Mail my regards to the guys who built that diesel. We could do with a lot more of 'em around here!"

Already, oilmen are experiencing the superior power service given by the new Ruston air-cooled diesels... the most advanced power units of their type . . . diesels with built-in stamina, traditional to Ruston manufacture. Extremely adaptable for all small-power applications in the oilfields, these diesels are superb in performance and their maintenance is child's-play. Every Ruston diesel goes into the field with a proved record of absolute reliability. Its prototypes have undergone the most comprehensive tests in one of the world's most modern engineering research centres... in temperatures ranging from −40 to 130°F and in conditions ranging from ideal to the impossible. Your plant will have *real* staying power if it's Ruston-powered.

RUSTON **air-cooled diesels**
4-87 b.h.p.

The power units backed by a first-class world-wide spares service to give you complete dependability.

RUSTON & HORNSBY LTD. · LINCOLN · ENGLAND
Associated with Davey, Paxman & Co. Ltd., Colchester, England

Representatives for Petroleum Industries: Beckley, Haltom & Hickman, The Americas Building, Rockefeller Center, 1270 Sixth Ave., New York 20, N.Y., U.S.A.

ent of Conoco's new Pecos district. He formerly served as assistant district superintendent at Odessa.

DEATHS

Fred Godfrey Moser, 73, independent oil operator, died June 30.

Orie N. Maness, 63, Tulsa independent geologist formerly associated with Margay Oil Co. and Dowell Incorporated, died June 2.

Paul Burton, 65, independent oil man, died June 14.

Kirk S. White, 57, independent oil producer and consulting geologist, died June 13. He was formerly associated with Tropical Oil Co. of Colombia and Pacific Petroleum Co. of Peru.

Matthew T. Murray, 47, geophysicist for the last eight years with Standard-Vacuum Oil Company, died May 29 at his home in Port Chester, N. Y.

Charles F. Bisett, 54, independent oil producer, died June 20.

Arch D. Kennedy, 71, retired drilling contractor, died June 22.

Ralph M. Barr, 58, who was widely known among oil men in Pennsylvania and Ohio, died June 24.

Meno M. Tripplehorn, 74, Tulsa oilman, died June 29.

C. Frank Redick, 76, who until his retirement in 1945 was the Ohio Oil Company's production superintendent at Yates field, Texas, died June 26, at his home in Spencerville, Ohio.

Hugh T. Poindexter, geophysicist and co-owner of Poindexter Exploration Co., died June 2 in a Houston hospital.

Hal S. Eddings, 50, vice president of Coastal Plains Oil Co., died June 3 in a plane crash at San Pedro Sacatepequez, Guatemala.

P. Floyd Hoss, 70, independent oil operator, died June 8.

Francis Blair, 52, oil man philantropist, died June 6.

Van Dean Hambright, 57, superintendent for The Texas Company lease at Fairfax, Okla., died July 27.

Harold Dean Reed, 38, geologist for Shell Oil Co., died July 21.

John W. Merritt, 73, Tulsa geologist, died July 19.

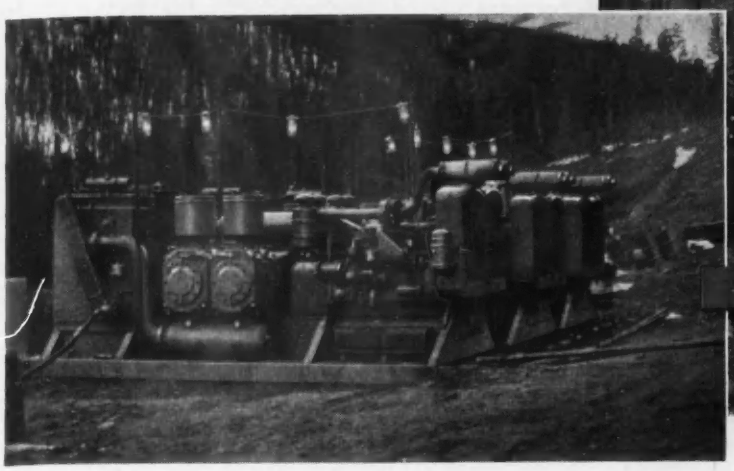
J. B. Lecount, 70, retired independent oil and gas operator, died July 6.

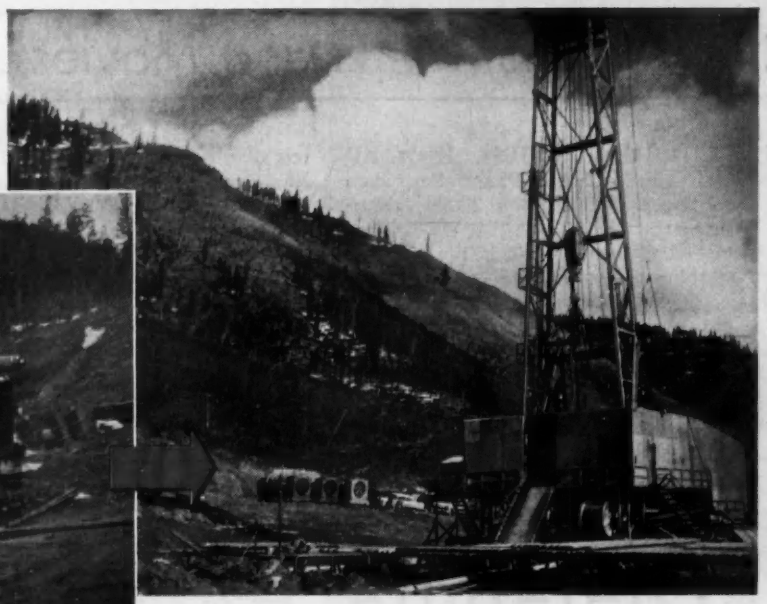
Charles M. Van Vleck, retired field manager for the Independent Petroleum Association of America, died July 1 in Tulsa. He retired from IPAA March 1, 1956, after 20 years of service with that organization.

William E. Moody, 74, retired vice president of Deep Rock Oil Co., died July 31.

For more data on advertised products, use Readers' Service Cards, last page.

Three Ingersoll-Rand packaged compressor plants serving a drilling rig in a remote, mountainous area of Canada, where dependability and freedom from maintenance are vital.





NEW compressor package for AIR DRILLING

...a rugged field-ready unit for continuous operation

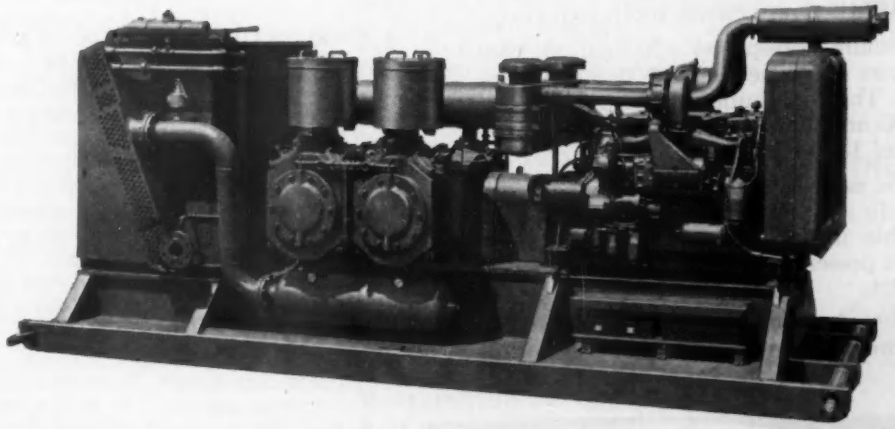
Here is a new skid-mounted compressor plant *designed for* air drilling—to give the air you need at the pressures you need, 24 hours a day for weeks. Just truck it to your drilling site, hook it up, and you're in business!

COMPLETELY SELF-CONTAINED—Skid-mounted unit contains heavy-duty Ingersoll-Rand balanced-design, two-stage HHE compressor; General Motors Twin 6-71 turbocharged diesel engine; combination forced-air cooler; all auxiliaries and controls. No extras to buy.

FAST, EASY STARTUP—Unit is so well-balanced and vibration-free that it needs no foundation; just set it on timbers, connect fuel line and discharge air lines and start it. It stays put and stays running.

COMPLETELY AUTOMATIC, SELF-PROTECTING—Adjustable regulator automatically maintains desired pressure; shifts from idling to running speed and loads or unloads compressor as required. Both engine and compressor are arranged for automatic shutdown in case of any malfunction.

LOW-COST MAINTENANCE—Self-protecting features enable operator to correct any trouble at source before damage is caused; maintenance is kept on simple preventive basis. World-famous Ingersoll-Rand Channel Valves give long, trouble-free service with sustained efficiency. Filtered, full force-feed lubrication systems for engine, compressor running gear and compressor cylinders keep wear to minimum.



Contact your Ingersoll-Rand representative now for more information on this new unit. It will make money for you by speeding your job.

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COMPRESSORS • GAS & DIESEL ENGINES • PUMPS • AIR & ELECTRIC TOOLS • CONDENSERS • VACUUM EQUIPMENT • ROCK DRILLS

New Books, Maps and Movies

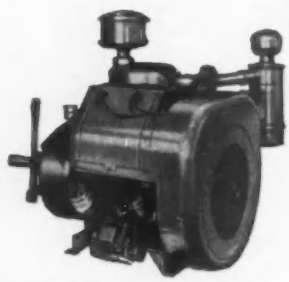
PETROLEUM REVIEW, HOWARD COUNTY, TEXAS, Phifer Petroleum Publications, P. O. Box 20024, Houston, $10.

This oil reference book is the eleventh in the series of books that has outlined the discovery, development and production in 13 counties of West Texas and New Mexico. The new 89-page book covers the 38 fields discovered in the county since Iatan-East Howard field in 1925. At the end of 1957, more than 275 million barrels of oil had been produced during the 32 years since the first discovery.

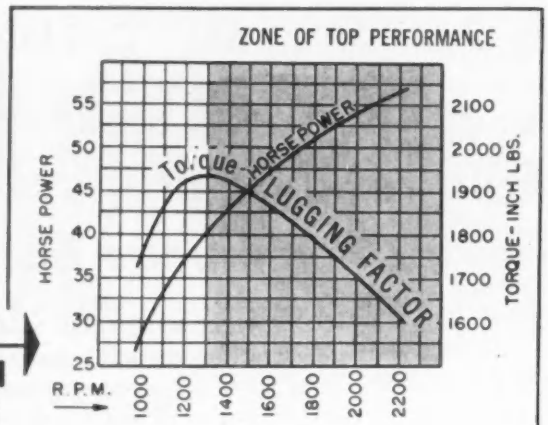
It was compiled by Robert L. Phifer from the records and hearing files of the Railroad Commission of Texas. In addition to the individual field histories of every field that has been discovered in the county, the book contains numerous subsurface structure maps presented as exhibits at the hearings in Austin, logs of discovery wells, a two-color map of the county and three quick-reference charts.

Judge your power unit by its

LUGGING FACTOR!



Model VR4D 56 hp



WISCONSIN *heavy duty Air-Cooled* **ENGINE** *power curve*

When the power load suddenly *builds up* and the engine speed *slows down* . . . how long will the engine *hang on* and carry the increased load without stalling?

The answer lies in the HIGH TORQUE LUGGING FACTOR which is an integral part of "Wisconsin" basic engineering. The point at which an engine will stall under suddenly increased loads is the *High Point* in the TORQUE CURVE. As a case in point, analyze the Wisconsin Model VR4D power curves reproduced here.

This engine develops its maximum horsepower (56 hp.) at 2200 rpm. at which point it registers a torque of 1600 inch-lbs. The engine runs into heavy going. The load builds up fast. The rpm. slows down to 2000, 1800, 1600 and 1400 rpm., reaching its maximum torque *at the low speed* of 1300 rpm.

In terms of power service to the user, this simply means that your Wisconsin Engine is designed *to provide dependable load-holding power at low engine speeds.* This, in turn, means fewer shutdowns, less wear and tear, more usable power and more versatile performance for your dollar investment.

These are reasons why it pays to specify "Wisconsin Power" for your equipment. For a briefing on the full line, write for Engine Bulletin S-223.

WISCONSIN MOTOR Corporation
MILWAUKEE 46 WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
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OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

A8-6218

THE FUTURE OF THE TANKER, Institute for Shipping Research, Bremen, by Dimitri A. Manthos.

The purpose of the book is to investigate from the point of view of the tanker owner, the probable requirements for oil tank vessels in the Free World in 1965. The method followed is to project the oil consumption separately for each country based on past figures and expected developments. Similarly the petroleum output, if any, is estimated, and from the two figures the imports or exports are derived.

The book is printed in both English and German.

THE FUTURE SUPPLY OF OIL AND GAS, The Johns Hopkins Press, Homewood, Baltimore 18, Md., by Bruce Netschert, $3.

Ample findings of domestic crude will be available from an estimated reserve of 500 billion barrels of oil and 1.2 quadrillion cubic feet of natural gas, the author says. These quantities will not necessarily be discovered or extracted, but are believed to exist for exploitation.

The author stresses technology as the leading factor in oil and gas determination. Traditional forecast techniques, particularly the proved reserve concept, are shunned in considering the longterm future.

THREE LEGGED ISLANDS, R. G. LeTourneau, Inc., 2399 South MacArthur, Longview, Texas.

R. G. LeTourneau, Inc., has announced availability of a new 18-minute color movie showing construction and operation of LeTourneau-built offshore platforms.

The two principal platforms discussed in the movie are the "Scorpion," which recently set a time record for relocation activity in the Gulf of Mexico, and the "Vinegarroon" which weathered hurricane Audrey with virtually no damage. Three others also are shown during construction stages at Vicksburg, Miss.

The 16 mm. sound movie is available for showings to petroleum groups without charge.

EFFECTS OF HYDRAULIC FRACTURING UPON OIL RECOVERY FROM THE STRAWN AND CISCO FORMATIONS IN NORTH TEXAS, U. S. Department of the Interior, Bureau of Mines, Publications-Distribution Section, 4800 Forbes St., Pittsburgh 13, Penn.

Hydraulic fracturing is credited with increasing crude petroleum output in a North Texas area by more than a million barrels during a recent two-year period, according to a Bureau of Mines report released by the Department of the Interior.

The report presents formations obtained in a lengthy study of 184 wells completed in two oil-producing formations known as the Strawn and the Cisco. Principal purpose of the Bureau's work was to determine whether hydraulic fracturing increased the amount of oil that could ultimately be recovered using primary-production methods.

what's Happening

among INDUSTRY ASSOCIATIONS

Committee Plans AAPG Regional Meeting

Southwestern Federation of Geological Societies will hold their annual regional meeting at Mineral Wells, Texas, October 22-25. Outlining the program for the sessions are, left to right, H. J. Fitzgeorge, Magnolia Petroleum Co., program chairman; E. L. Smith, independent, vice chairman; J. H. Pittinger, Shell Oil Co., general chairman; N. G. Creager, Continental Oil Co., secretary-treasurer. All are members of the North Texas Geological Society, sponsor of the meeting.

Austin Attorney Is Named Exec-Secretary of AAODC

James E. Danheim, attorney of Austin, Texas, has been named the new executive-secretary of the Association of Oilwell Servicing Contractors. He takes the position formerly held by W. H. (Woody) Fox, who resigned recently.

Canadian Gas Group Picks Officers and Directors

Dr. Henry L. Purdy was elected 1958 president of the Canadian Gas Association during its fifty-first annual meeting held in Murray Bay, Quebec, recently. He succeeds H. C. Darroch of Toronto. Dr. Purdy is executive vice president of the B. C. Electric Co. Ltd.

Other exectuive officers elected are N. E. Tanner, chairman of Trans-Canada Pipe Lines Ltd., as first vice president; R. C. McPherson, senior vice president of Canadian Western Natural Gas Co. Ltd., second vice president.

Directors include W. H. Dalton, managing director of the association; D. Cass-Beggs; T. E. Cross; K. Lucas; J. R. Reeves; G. M. Douglas; John Hobbs; H. C. Darroch; G. E. Downie; J. W. Ostler; C. R. Hetherington; E. H. Rohrer; and Bruce Willson.

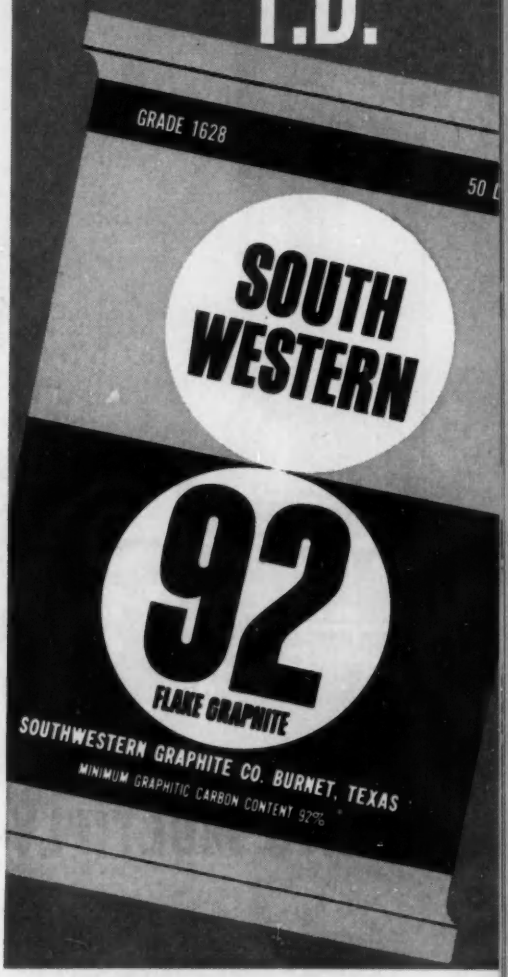
McGonagill to Speak To Gulf Coast Geologists

Frank E. McGonagill, Jr., vice president, Oil and Gas department, Bank of the Southwest, will appear as guest speaker for the Gulf Coast Association of Geological Societies meeting in Corpus Christi on October 28.

Washington Becomes 29th Full Member of IOCC

The state of Washington became a full member of the Interstate Oil Compact Commission when Albert D. Rosellini, governor of the state of Washington, affixed his signature to the Compact agree-

SLICKEST WAY TO T.D.



USED AND RECOMMENDED

. . . *especially* under conditions where TORQUE, DRAG, OR THE HAZARD OF STICKING DRILL-STEM AND CASING are encountered.

FIVE YEARS OF FIELD EXPERIENCE

have proved the effectiveness and versatility of

SOUTHWESTERN FLAKE GRAPHITE

Available through your mud dealer.

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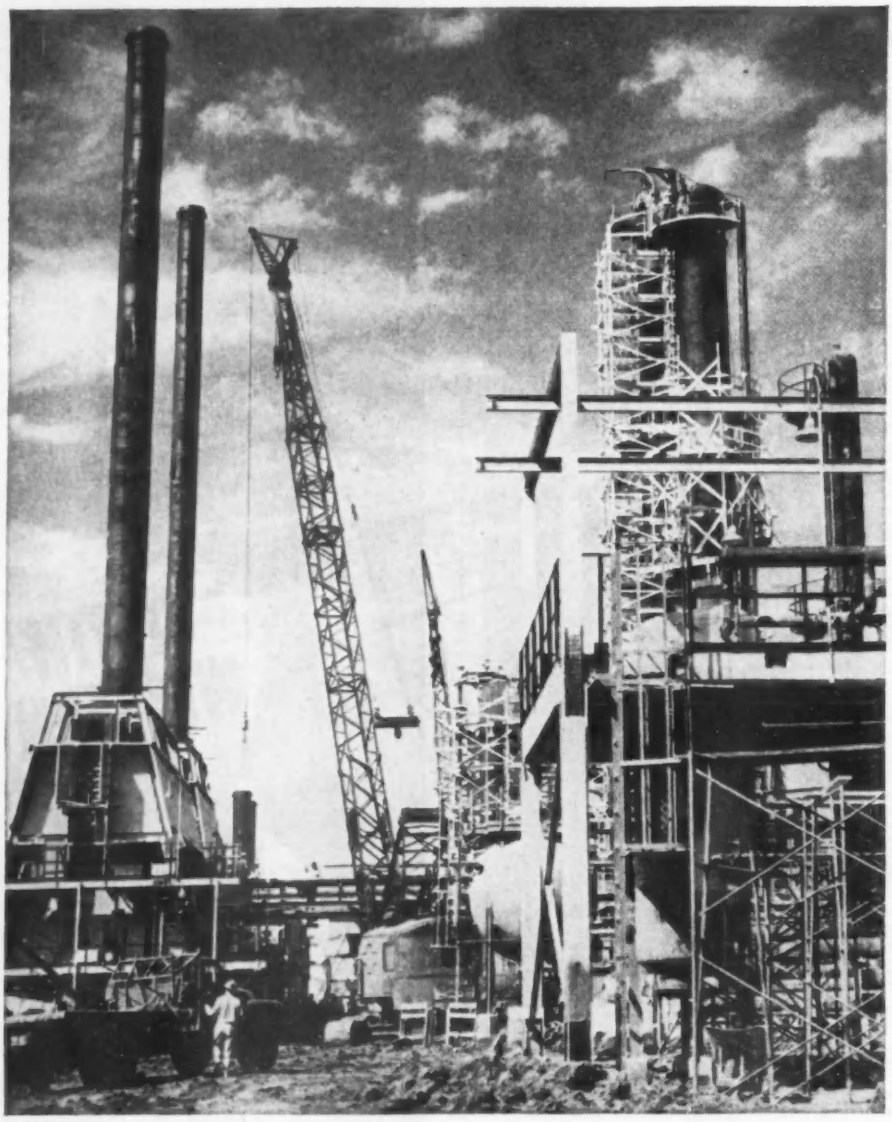
BURNET, TEXAS



CATS MULTIPLY FAST IN CANADA

Nowhere is Canada's swift industrial progress more striking than in the recent development of its oil refining and petrochemical facilities. Canada's daily refining capacity already approaches 700,000 barrels. New petrochemical plants are rising from coast to coast, to meet the demand for paints, alcohol, ammonia, plastics, detergents, synthetic rubber and other products of petroleum or natural gas.

U. S. executives interested in any branch of the oil and natural gas industry in Canada will find a useful ally, and a prompt, dependable source of information in The Canadian Bank of Commerce. Write or telegraph direct to C. H. Munro, Manager, Petroleum and Natural Gas Department, 309 Eighth Avenue, West, Calgary, Alberta, or to our Business Development Division, Head Office, Toronto 1, Canada.

(*We regret that we cannot advise on the merits of oil or mining securities*)

THE CANADIAN BANK OF COMMERCE

Head Office Toronto 1, Canada

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ment recently. Washington formerly had been an associate member of the commission, but with the discovery of oil in that state became eligible to become a regular member.

The Interstate Oil Compact Commission now consists of 29 member states and two associate member states.

Exploration Geophysicists Form Eighteenth Section

Exploration geophysicists in the "Four Corners" area of Colorado, New Mexico, Arizona and Utah have organized the eighteenth local section of the Society of Exploration Geophysicists.

The 56 charter members elected David B. Davidson, president; R. P. Thomas, first vice president; J. W. Rogers, second vice president; John P. Badami, secretary; and V. Frank Hinson, treasurer. George W. Sanders and James M. Watson were nominated for representative to the twenty-eighth annual international meeting of SEG, October 13-16, in San Antonio, Texas.

Joseph Jensen Elected Oil Conservation Head

The Conservation Committee of California Oil Producers held its annual election of officers recently. Joseph Jensen, of Tidewater Oil Company, was elected chairman for the ensuing 12 months.

The other officers elected were first vice chairman, O. A. Graybeal; second vice chairman, M. C. Eastman; and secretary, T. H. Acres.

Canadian Oil Group Exhibit Is on Display in Ottawa

The Canadian Petroleum Association has been requested by the Mineral Resources Section of the federal government's Department of Northern Affairs and National Resources to assemble an exhibit under the title "Oil Industry North of the 60th." The display, depicting oil and natural gas exploration and development north of the 60th Parallel, has been on public show on the third floor of the Kent-Albert Building, 150 Kent Street, Ottawa, for six months beginning August 1.

The centerpiece for the display is a working model of an oil rig.

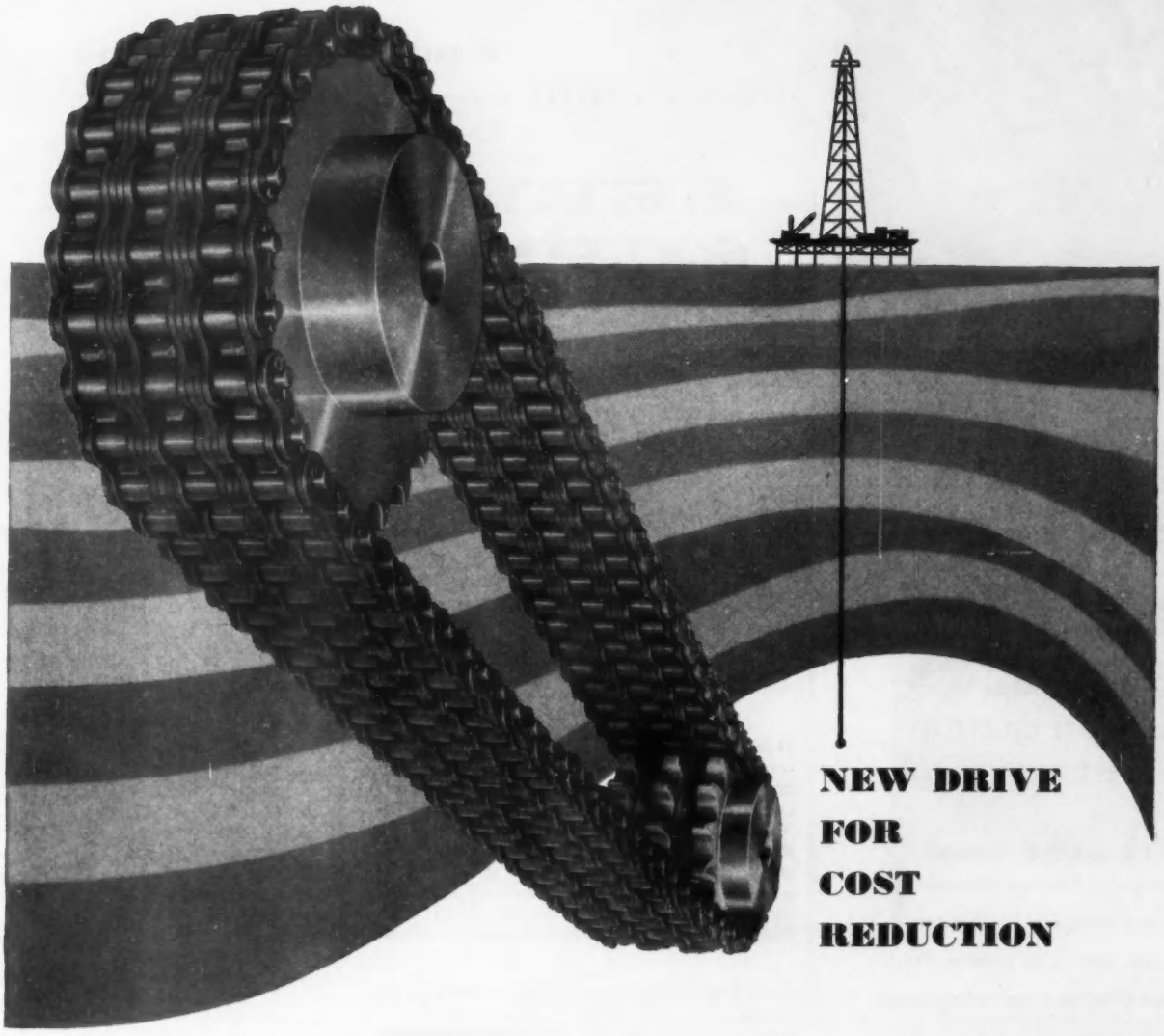
Exploration Geophysicists Grant 25 Scholarships

The third annual award of university scholarships in geophysics has been made by the Scholarship Fund of the Society of Exploration Geophysicists.

Twenty-five scholarships will be granted by individual companies interested in the geophysical profession and two scholarships financed by the organization's general fund. The 1958-59 educational grants will total $21,000 and will be taken in 17 universities. This is an increase of $9,000 in scholarship funds as compared to 1957 and represents 12 additional scholarships.

Companies granting one or more full-year scholarships under the SEG plan are Grant Body and Equipment Company, Ramsey Winch Company and Bevan-Handley Company of Tulsa; Mayhew Supply Company, Griffin Tank and Welding Service, Renwar Oil Corporation and Geophysical Service, Inc., all of Dallas; Texas Gulf Sulphur Company, Independent Exploration Company, Schlumberger Well Surveying Corp., Herb J. Hawthorne, Inc., Vector Manufacturing Company, Southwestern Industrial Electronics Co., and the Houston Geophysical Club, all of Houston.

For more data on advertised products, use Readers' Service Cards, last page.



NEW DRIVE FOR COST REDUCTION

Whitney's *new* chain drive developments are helping to reduce oil field production costs *where it counts* . . . keeping rigs operating under the toughest shock loads and punishment that drilling schedules can hand out.

Here's why important producers everywhere are specifying these new cost-cutting chain drives:

√ An exclusive *fatigue-resistant* Whitney Process offsets *excessive operational stresses* in the chain —assures new durability and freedom from excessive wear, breakage and dollar consuming downtime. Each precision Whitney Chain part is specifically designed, heat treated and assembled to meet your severest service requirements.

√ And Whitney's *"Fluid-Fit"* design features all cottered chain construction with slip-fit link assemblies . . . no tough, time wasting repair work when assembling or adjusting your chain drives.

√ Another important design advance is Whitney's High-Capacity Roller Chain. This new, *compact* chain drive may provide an engineered solution where space limitations and higher horsepower requirements are important factors in power transmission.

Backing up these design advances is Whitney Chain *service* . . . a complete line of packaged, precision steel chain, always available from oil country warehouses and oil field supply stores everywhere. Each point brings you field *engineering service* and prompt delivery from stock. Write for complete, practical catalog literature.

Whitney

CHAIN COMPANY

323AK Hamilton St., Hartford 2, Conn.

ROLLER CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS • WHITNEY-TORMAG DRIVES

WHEN GAS PRESSURE IS HIGH DEPEND ON DEMCO TO...

PREVENT BLOW-OUTS

DEMCO

COMBINATION CASING & BLOW-OUT PREVENTER TESTER . . .

A DOUBLE-DUTY TOOL

for testing casing and blow-out preventer. In areas of unknown or expected high pressure, this DEMCO tool acts as a positive check against blow-out preventer—and tests casing for weak spots or leaks!

This dual-purpose tool is used by major companies and contractors throughout the world.

PLUS FACTORS

- WITHSTANDS ANY REQUIRED TEST
- FITS AT ANY POINT IN DRILL STRING
- TESTS WITHOUT PRESSURE ON FORMATION
- REMOVED FROM CASING WITHOUT PULLING VACUUM OR SWABBING
- ADAPTABLE IN 3 BASIC MODELS TO FIT ALL CASING SIZES

DEMCO DRILLING EQUIPMENT MFG. CO. OKLAHOMA CITY, OKLA. U.S.A.

WRITE TODAY FOR DETAILS

DRILLING EQUIPMENT MANUFACTURING CO.

P. O. BOX 4728 • OKLAHOMA CITY, OKLA

What's Happening among SERVICE and SUPPLY MEN

T. P. Tarwater has been named president of **CP-Harrisburg, Inc.** Former President **Ken W. Davis** is now chairman of the board. Tarwater was formerly general manager of sales of Mid-Continent Supply Co. He had been with Mid-Continent since 1936.

T. P. Tarwater

Wilson Supply Company, with headquarters in Houston, recently announced the transfer of **James Grady Ferguson** from the Houston office to the sales office in Tulsa, where he will assist **P. S. (Phil) Stover,** manager. Ferguson has been with the company 12 years. He is being replaced in the Tubular Goods department by **Herbert Reimers,** who has been with the Wilson Supply Company for 17 years.

G. Turner Armstrong has been named vice president and manager of Research and Development for **Welex, Inc.,** with offices in the Welex Research and Development Center in Houston. Armstrong moved to the Houston position after serving as vice president and division manager of the company's North Texas-Panhandle division with offices in Dallas.

G. T. Armstrong

Ame Vennema, vice president—personnel relations for Schlumberger Well Surveying Corporation, has been elected vice president—administration and chief of staff of **Schlumberger Ltd.**

Southwestern Industrial Electronics Company, a division of Dresser Industries, Inc., announced several staff appointments and promotions. **Warren C. Dunn** comes from Union Switch and Signal division of Westinghouse Air Brake to be assistant to Executive Vice President **Richard H. Parker.** Heading each area of SIE interests in the position of production manager are **Louis B. McManis** (Geophysical division), **Frank C. Smith, Jr.,** (Instrumentation division), **Newton E. Armstrong** (Control division), **Robert L. McCelvey** (Government Contract division), and **Albert B. Dustin** (Inter-Company and Heavy Manufacturing division), all of whom are appointed from within the company.

Richard E. Jenkins, administrative sales manager for Clark Brothers Co., Olean, N. Y., has been named assistant general sales manager with supervision of all Clark district and branch offices west of the Mississippi River.

John P. Kadlic was appointed New York district sales manager for the Wire Rope and Aircord division of **John A. Roebling's Sons Corporation.** Kadlic replaced **Earl A. Frazier,** who now heads the division's Seattle territory.

W. L. (Sam) Melton has been named by the **L-K Pump Valve Company** of Houston as sales and service engineer. Melton is the inventor of the L-K oil sample heater, the Melton heating centrifuge, the L-K heating hydrometer cylinder and other products. His territory will consist principally of East Texas, northern Louisiana, Arkansas and Oklahoma.

W. L. (Sam) Melton

Norvell-Wilder Supply Co. announced the appointment of **W. D. (Bill) McGhee** as manager of the company's new sales office at Baton Rouge, La.

John M. Thomas has resigned as vice president of **H. C. Price Company,** and his duties will be assumed by **Harold C. Price, Jr.** Thomas, who maintains his association with the company as a member of the Board of Directors of H. C. Price Company and H. C. Price of Canada, Ltd., had been with the organization since 1937.

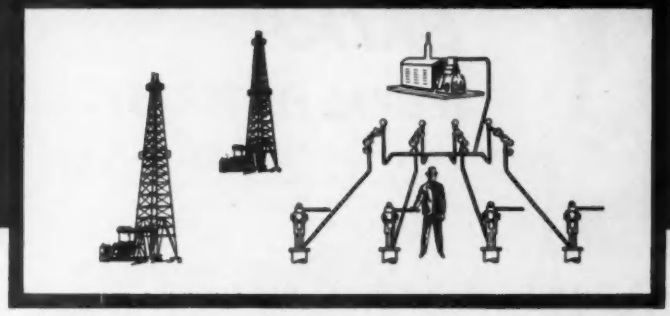
Dick M. Koons has been appointed director of the Research and Development department for **Otis Engineering Corp.**

Cyrus V. Helm assumed duties as Midland division manager of **The Western Company.**

Victor V. Graf, former manager of research, engineering and supply for Seismograph Service Limited in England, was appointed to the post of assistant to the president of **Seismograph Service Corp.,** G. H. Westby, SSC president, announced.

Eugene Ransom has been appointed general manager of the Industrial Hose division at **Flexonics Corporation.** Before his new appointment, Ransom was on special assignment at Flexonics' Memphis, Tenn.,

WATCH SARGENT PUMP PERFORMANCE



UNDER THE TOUGHEST FIELD CONDITIONS

For 38 years Sargent has successfully worked in research, development and manufacture of oilwell, aircraft, marine, missile, and electronic equipment. The vast knowledge and experience gained through successfully engineering and manufacturing products in these highly advanced fields has been incorporated into building the finest pumps in the oilfields. Sargent builds every API classified pump obtainable with metals to fit any and all well conditions.

In 1924 the first Sargent hydraulic pump patent was obtained (patent #1,503,602).

Through years of research, re-design and refinement, Sargent now manufactures the pump proven to be the most efficient rodless, long stroking, bottom hole hydraulic unit obtainable, which actuates the time-proven bottom hole pump. Sargent provides the most complete service in the industry by company trained experts through company operated field stores.

The outstanding features of the Sargent rodless, long stroking, free or conventional design hydraulic pump are: • More volume • Wide selection of proven metals and design • Higher efficiency in gassy wells • Simple, yet rugged construction • Service in the fields (at the point of operation).

That's why you can "Watch Sargent" pump performance anywhere in the world under the toughest field conditions and learn for yourself that results prove "Sargent Builds 'em Better"!

"GOOD WILL" is the disposition of the pleased customer to return to the place where he has been well treated.
— U.S. Supreme Court

Standard of Excellence *Since 1920*

SALES AND SERVICE

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Bakersfield
Santa Maria
Ventura
Taft
Huntington Park
Santa Fe Springs

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NEW MEXICO
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COLORADO
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Midland*
Sundown
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Quitman

ILLINOIS
Grayville

ARKANSAS
Magnolia

KANSAS
Chase
Russell
Great Bend*

* Sales Representation

Sargent — QUALITY BUILDS GOOD WILL

ENGINEERING CORPORATION

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HUNTINGTON PARK, CALIF.

plant. Ransom succeeds **E. W. Driedger**, who resigned from Flexonics. **James R. Strother** has been appointed sales manager of the Industrial Hose division. **John F. Fisher** is division factory manager, **L. B. Donkle** is division engineering manager, and **J. A. Downey**, production manager.

S. E. Culwell was appointed branch manager of **McCullough Tool Company's** Healdton, Okla., service branch.

Franklin Supply Company announced the appointment of **Clarence Sublett** as vice president in charge of Franklin's Midwest operations headquartering at East Chicago, Ind. **William Carroll** has been appointed vice president in charge of Franklin's New York office and Export division.

J. C. Smith has been appointed sales manager for **OTM Corporation.**

Harold F. Allen, chief engineer of **Link-Belt Speeder Corporation**, subsidiary of Link-Belt Company, retired recently, and was succeeded by **Frank J. Strnad.**

Birdwell, Inc., named **Lloyd C. Fons** Mid-Continent division manager.

Travis Griffin was promoted to the post of branch manager in Hobbs, N. M. Griffin joined Sivalls Tanks in 1957, and worked in Odessa until his transfer to Hobbs early this year. Working with Griffin in Sivalls' Hobbs branch is **Frank Harrell**, sales and service man.

George E. Matter has been named executive vice president and general manager of **Homco International, C. A.**

The George Engine Co., Inc., has recently announced two major changes in their executive roster.

H. J. Lopez, Jr.

James A. Cobb is the newly-appointed secretary of the corporation. Cobb formerly held the position of comptroller and will continue in this post after assuming his new duties as secretary-comptroller. **H. J. Lopez, Jr.**, has been named credit manager of George Engine, succeeding **George G. Grant**, who is no longer with the firm. Lopez is also assistant treasurer and advertising manager of the company.

Rodney G. Morrison has been appointed district engineer of the Saskatchewan-Manitoba district of **The National Supply Company, Ltd.** He will have his headquarters at Regina, Sask.

McCullough Tool Company made the following changes in its Eastern division Sales department. Sales representative **W. S. Hemphill**, formerly in the Victoria, Texas, area, has been transferred to McCullough Tool Company's Houma, La., location; **D. B. Petty**, sales representative, has been transferred from Wewoka, Okla., to McCullough's Hominy, Okla., branch office.

Patrick Bradley has been named manager of distributor sales of **American Hoist and Derrick Company.**

•

Burtram McClain has been named general manager of **Aero Service Corporation**, Philadelphia. McClain will be in charge of all operations of the company and its domestic and foreign affiliates. He will also continue his functions as the company's chief financial officer.

•

Atlas Powder Company announced several major changes among top-level personnel, including the election of Atlas President **Ralph K. Gottshall** as chairman of the board, in addition to re-election as president. As chairman of the board, he succeeds **Isaac Fogg**, who retired after nearly 46 years of service. Fogg will remain as a director, member of the Finance Committee and chairman of the Committee on Audit. The board also announced the election of **Edward J. Goett**, senior vice president, to the position of executive vice president. Other changes announced included: **Robert J. Reilly**, assistant treasurer, elected treasurer and secretary, succeeding **Preston W. Parvis**, who also retired after more than 47 years of service. Parvis remains a member of the board and was appointed a member of the Committee on Audit. **John H. Leary**, assistant to the president, elected assistant treasurer and assistant secretary.

Officers re-elected were vice presidents

EXTRA

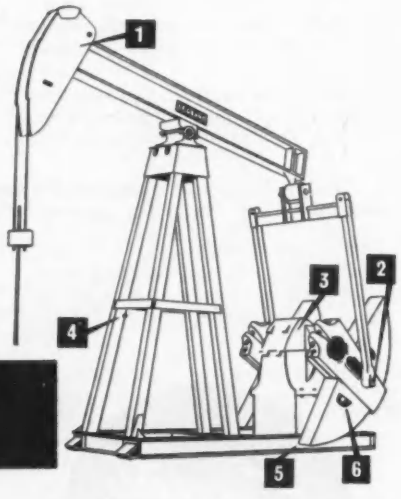
SPECIAL FEATURES

The more distinctive and original the facial adornments of this New Guinea tribesman the more important he becomes in the eyes of his fellows. The character illustrated is wearing the Australian Government's Service Medal on his brow, and the cap badge of a shot down airman in his cowrie headband. Many other adornments from wrecked Allied and Japanese aircraft are worn to give distinction to the owner.

Much more appreciated by oilmen in the field are the extra special features of the Le Grand Pumping Units which make them so rugged—dependable—reliable.

Note these outstanding features:

1. Swing back mulehead provides ample well clearance for well servicing. Mulehead retaining bolt operated from samson post.
2. Patented wrist pin for ease of changing stroke; no seizure occurs requiring hammering or burning out to remove.
3. Double reduction, double helical gears with anti-friction bearings throughout.
4. Inbuilt oil reservoirs provided in bearings with lubrication points at shoulder level throughout, using one grade of oil throughout.
5. All units have floor clearing cranks.
6. One man operated counterbalances in one horizontal setting of the cranks.



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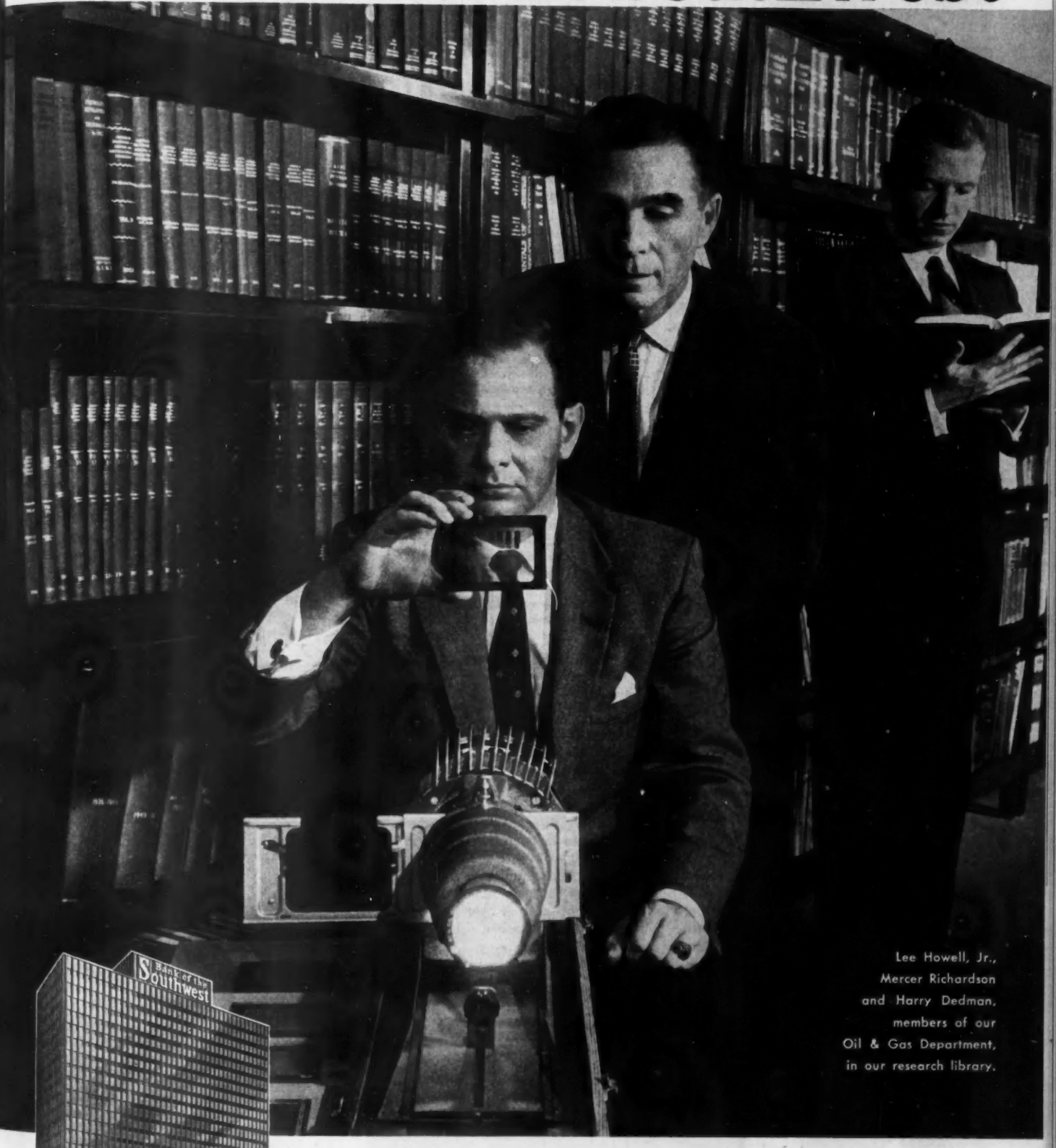
TRINIDAD: Industrial Agencies Ltd., 14, High Street, San Fernando, Trinidad, B.W.I.
VENEZUELA Eastern: A-Z Export, S.A., Apartado 4062, Puerto La Cruz, E. Venezuela
VENEZUELA Western: A-Z Export, S.A., Apartado 304, Maracaibo, W. Venezuela

OIL Bank of the Southwest



Lee Howell, Jr., Mercer Richardson and Harry Dedman, members of our Oil & Gas Department, in our research library.

BANK OF THE SOUTHWEST offers the ultimate in scope and quality of financing to the petroleum industry. The seasoned members of our Oil & Gas Department were oil men before they were bankers. A large number of our directors and Advisory Committee also are oil men. That's why our bank is known as the Oil Bank of the Southwest. For information, write Harold Vance, vice president and manager, Oil & Gas Department.

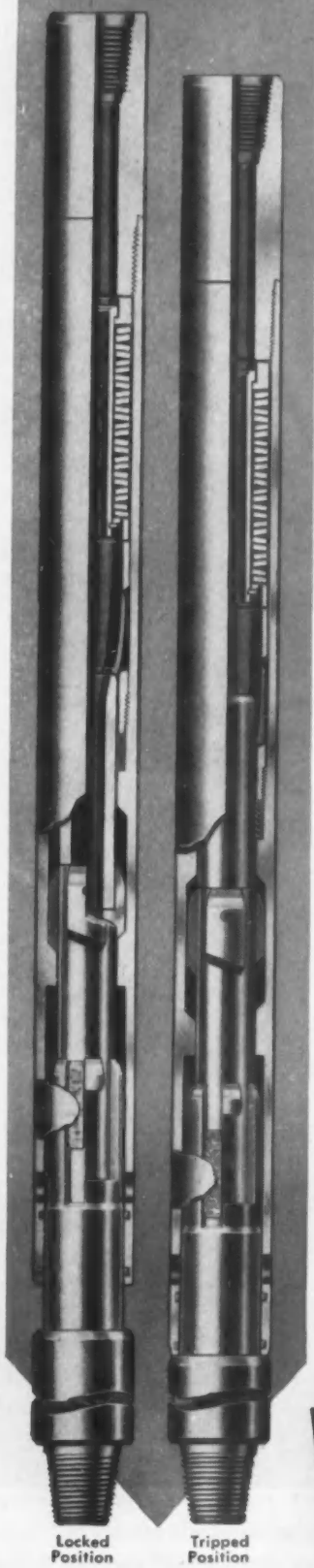
BANK OF THE SOUTHWEST • HOUSTON

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

For running in the drill string . . .

Positive JAR-DOWN ACTION

. . . plus Safety Joint protection!

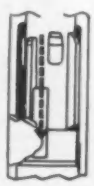


See the Shaffer section of your Composite Catalog.

THE SHAFFER-WAGGENER BUMPER SAFETY JOINT

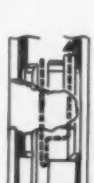
There is no other tool like the Shaffer-Waggener Bumper Safety Joint. It combines—in ONE tool—a choice of *jar-down* and *releasing* actions, both under complete control of the operator. What's more, the tool is so rugged it is run as part of the drill string to protect against stuck pipe.

In actual well service it has operated easily at depths below 18,000 feet, and has given no operating problems even in directionally-drilled wells with extreme slant.


Jar-Down Action

RUN IT IN THE DRILL STRING—It is specifically designed to withstand the continuous vibration and heavy torque loads of today's drilling operations.

TO JAR DOWN whenever the drill pipe threatens to stick—or to drive drill collars out of keyseats and to free "balled-up" bits—simply slack off weight equivalent to about 2,000 feet of drill pipe onto the tool. This releases the tripping mechanism, automatically striking a sharp *down* blow. Raising the string automatically re-sets the tool for another blow—and blows can be struck repeatedly as fast as the string can be raised and lowered. And no torque or twisting strains are placed in string!


Releasing Action

TO RELEASE, in the event jarring will not loosen the stuck string, simply trip the tool and apply reverse torque as the string is slowly raised. Only one-sixth turn of the tool rotates the drive keys into unlocking slots so that complete release is effected by continuing to raise the string.

ANOTHER ADVANTAGE—the tool transmits full torque loads in *either* direction through three rugged drive keys—not through easily-damaged threads. It is the strongest joint in the string—not the weakest, as with conventional safety joints.

Also, the tool can be re-connected again by simply lowering the top portion over the lower portion and reversing the releasing action. It is ideal for use in fishing strings!

Free 8 page bulletin gives the full story on the Shaffer-Waggener Bumper Safety Joint. Write for it—or ask your nearest Shaffer representative.

James R. Frorer, Charles C. Gammons and **William C. Lytle;** and **Arnold J. Fiedler,** assistant treasurer and assistant secretary.

Art Morton has been named division sales manager of the Houston division with **Paul Ferguson** transferred to New Orleans as sales manager of the South Louisiana division of the **Harold Brown Company.**

David P. Wroten has been appointed district manager, Southeastern territory, for **W-S Fittings Works, Forge and Fittings Division, H. K. Porter Company, Inc.**

E. A. Kunnemann

E. A. Kunnemann has been appointed Mid-Continent sales engineer for **H. C. Smith Oil Tool Co.** Kunnemann will service the entire Mid-Continent area for the company and will be temporarily located in Houston. Later in the year he will set up permanent headquarters in Odessa, Texas.

Jones & Laughlin Supply Division has made some changes in its field sales organization. **W. C. Blackledge,** store manager for J&L at Laurel, Miss., is assigned as salesman at Laurel. **H. E. Reeves,** sales trainee, is appointed salesman at Brookhaven, Miss. **G. R. Cain,** storeman at Hobbs, N. M., is promoted to salesman and assigned to the Kermit store. **D. R. Williams,** salesman at Snyder, Texas, is transferred to Tulsa in the same capacity. **P. V. Ray,** salesman at Alice, Texas, is transferred to Pleasanton, Texas.

Tom Manuel, formerly Salt Lake City district manager for **Christensen Diamond Products Company,** and **Hugh Wallace** of the Oklahoma City district, are being transferred to Christensen's affiliate company Christensen Diamond Products Company (France). Manuel will be located in Celle, Germany, where he will work through a subsidiary company—Christensen Diamond Products GmbH. Wallace will be stationed in Rome, Italy, where he will work with special foreign sales representatives in the servicing of customers throughout Italy, the Near East and Africa.

Royal W. Reiss was named engineer in charge of the oil and gas operations of **Aluminum Company of America,** with headquarters in Houston. He will report to **Lawrence Litchfield, Jr.,** Alcoa vice president.

W. R. Wheeler, Jr., has been elected vice president in charge of sales at **American Iron and Machine Works Co., Inc.**

Armco Steel Corporation announced a number of changes in organization. **C. W. Rowles,** formerly assistant controller, has been elected controller and will serve in a company-wide staff capacity. **G. E. Humphrey,** formerly statistician, and **E. A. Rickling,** formerly chief general accountant, have both been named assistant controllers. The general controlling function will continue under the direction of **D. E. Reichelderfer,** vice president—finance. **D. C. Boone,** formerly assistant controller, has

been appointed controller for the Armco division.

L. H. Juengling, vice president, formerly in charge of operations of the Sheffield division, has been transferred to general headquarters and placed in charge of purchasing and traffic. **J. S. Thomas,** formerly director of purchases, will assume additional responsibilities as general director of purchases for the entire company. A number of changes are being made in the organization of the Sheffield division. **R. F. Kuhnlein,** formerly manager of the Kansas City works, has been elected vice president—Sheffield operations, succeeding Juengling. **R. C. Rhoades,** formerly superintendent of bolt and forged products, has been appointed works manager, Kansas City. **E. H. Thorsteinson,** formerly vice president and controller of National Supply, has been appointed assistant to the president.

L. T. Johnston, formerly vice president—sales, has been elected executive vice president and will assume increased general staff duties in addition to his responsibilities in connection with sales of both steel divisions and the four subsidiaries. **W. B. Quail,** formerly general manager of Armco division sales and **W. S. Newell,** formerly general manager of Sheffield division sales, have ben elected vice presidents of the company in charge of steel sales in their respective divisions. **G. R. Graham,** formerly assistant controller of National Supply, has been elected controller of that company. **C. W. Beck,** formerly manager of raw materials purchases, has been appointed director of purchases for the Armco division reporting to **C. G. Davies,** vice president of that division.

J. C. Mabe was elected vice president in charge of plant operations of **Chicago Pneumatic Tool Company.**

I. B. Allen has been appointed Venezuelan representative for **Rolo Manufacturing Company,** of Houston. He will make his headquarters in Caracas.

Gerald Pope, assistant general sales manager has advanced to general manager of sales of **The J. B. Beaird Company, Inc.** Pope succeeds **Melvin A. Finuf,** who has moved up to the staff of the executive vice president as marketing assistant.

Joe W. Bull has been transferred to Houston to fill the position of city salesman of the **Milwhite Mud Sales Company,** a subsidiary of the Mississippi River Fuel Corporation. Bull has been with Milwhite for the past five years as an engineer in West Texas and city salesman in Dallas and Fort Worth.

L. C. Taylor has been transferred to Henderson, Ky., where he will be sales engineer for the Dowell division of **The Dow Chemical Company.**

Woodrow Heard was appointed works manager for **Brown Oil Tools, Inc.** In his new post, he will have direct supervision of all manufacturing facilities, shop personnel, shop requirements of materials and supplies and tool engineering.

American Hoist & Derrick Company announced the appointment of **George F. Manikas** to the position of general manager of the **Crosby-Laughlin Division** of American Hoist.

Dr. Clark D. Goodman, nuclear physicist, was appointed **Schlumberger Well Surveying Corporation** vice president and direc-

For fishing, testing and core-drilling strings . . .

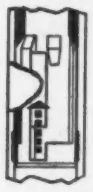
. . . plus Safety Joint protection!

Positive JAR-UP ACTION

THE SHAFFER OIL-SEALED JAR SAFETY JOINT

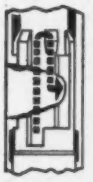
The Shaffer Oil-Sealed Jar Safety Joint is the only tool that combines a choice of *jar-up* and *releasing* actions, both under complete control of the operator at all times. What's more, all operating parts are sealed in a chamber filled with clean oil, fully protected against mud, sand and corrosive fluids.

The sealed-in-oil protection not only safeguards against abrasion and corrosion, and minimizes pressure differentials on packing elements, but also insures constant operating characteristics at all depths. This makes the tool ideal for fishing, testing and similar strings where light connections and equipment are used!



Jar-Up Action

JARRING ACTION IS AUTOMATIC—simply raise the drill string until tension equals the pre-set tripping load, whereupon a sharp up blow is struck. Lowering the tool automatically re-sets the tripping mechanism for another blow—and repeated blows can be struck as fast as the string can be raised and lowered.



Releasing Action

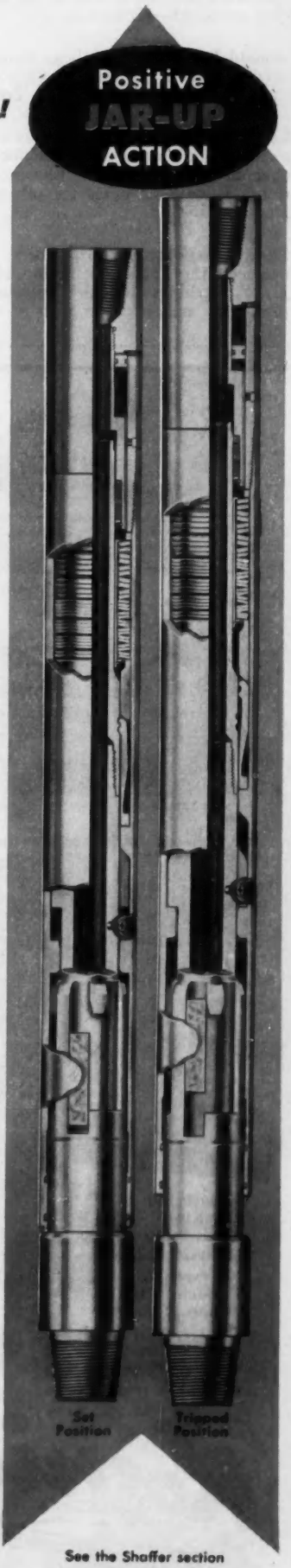
ONLY STRAIGHT PULL is necessary to operate the tool—no torque or other secondary operations to affect the light connections commonly used in fishing, testing and coring strings.

TO RELEASE, in the event the fish or stuck string cannot be loosened, simply trip the tool and apply reverse torque as the string is slowly lowered. Only one-sixth turn of the drive keys rotates them into an unlocking slot whereupon raising the string allows the parts to unlock.

AND NOTE THIS—not only does the tool transmit full torque loads in *either* direction, but no threads are used in the releasing mechanism. Therefore there's no risk of torque over-tightening the tool—nor can reverse rotation accidentally release it.

Also, force of the blow is absorbed by integral knocker heads—not by easily damaged drive keys or threads. The tool is designed for *sustained* jarring operations. And since it does not depend upon friction for its tripping action, the Jar Safety Joint always operates with the same pre-set action. Light strings are not subjected to unpredictable loads!

Free 8 page booklet gives many other facts about the Shaffer Oil-Sealed Jar Safety Joint. Write for it—or ask your nearest Shaffer representative.



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HIGH PRESSURE DRILLING AND CONTROL EQUIPMENT • FISHING TOOLS THAT EXCEL

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35 years OF OIL TOOL LEADERSHIP

See the Shaffer section of your Composite Catalog.

tor of research at the company's Research Laboratories in Ridgefield, Conn. Dr. Goodman will serve under **A. Blanchard,** vice president—technique.

Donald E. Graham has been named to the newly created position of executive vice president of **H. C. Smith Oil Tool Co.**

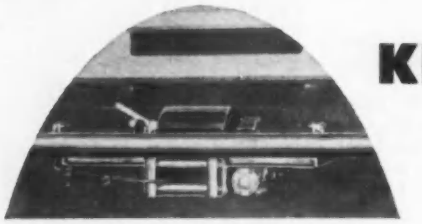
Loffland Brothers Company has announced the appointment of **W. J. Price** as manager of that company's European operations. Price will open an office in The Hague, Holland.

Parkersburg-Aetna Corporation has announced the appointment and election of **J. W. Robbins** to the position of vice president and general sales manager of **The Parkersburg Rig & Reel Company,** division of Parkersburg-Aetna. Robbins succeeds **A. G. Evans-Lombe,** who resigned as general sales manager and will continue as vice president.

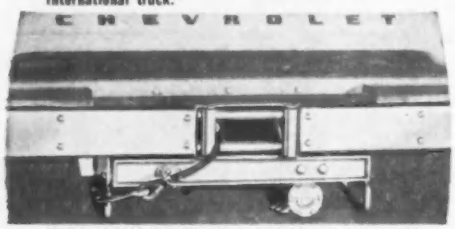
Oil Field Sales & Services Is Distributor for Axelson

The Axelson Manufacturing Company, Division of U. S. Industries, Inc., has appointed Oil Field Sales & Service, S. A., as distributor for their subsurface pumps and sucker rods.

The complete Axelson inventory of parts and repair equipment has been purchased by Oil Field Sales & Service from Axelson's former distributor, Servicios Industriales, C. A.

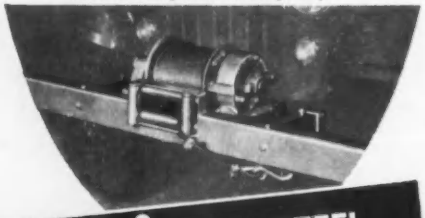


Model A-11 King Winch on A-120 (4x4) all-wheel-drive International truck.*



Model CD-8116 King Winch on 1958 Chevrolet Model 31 (4x4).

Model 151J King Winch on Willys Jeep.



KING WINCHES

. . . for Willys, International, Chevrolet, GMC, Ford, Land Rover and other vehicles

COMPLETE, READY-TO-INSTALL KING FRONT-MOUNT WINCH ASSEMBLIES FEATURE:

- winch side arms to reinforce truck frame
- bronze-bushed, 4-way cable guide rollers
- cable drum guard
- heavy-duty pipe bumper
- needle-bearing, universal-joint spline-shaft drive assembly
- Timken bearings on worm

King Winches keep you moving through the most difficult terrain . . . you get action where there's no traction with dependable pulling power. King power winches have pulling capacities of 8,000 to 19,000 lbs.

* *King Winches for International trucks are available through International-Harvester dealers.*

Koenig ALL-STEEL CABS FOR JEEPS

FULL AND HALF CABS

Koenig Jeep cabs and King Winches for Willys vehicles are available through Willys Motors, Inc., and Willys-Overland Export Corp. distributors or dealers. Write for free descriptive literature.

Full Cab and Model 151J King Winch Illustrated.

KOENIG ALL-STEEL CABS HAVE THESE SUPERIOR FEATURES:

- PROTECTION
- SAFETY
- COMFORT
- CONVENIENCE

Roll-down windows, full opening . . . full panel-board head lining and masonite door lining . . . safety glass throughout . . . all-steel welded construction . . . door locks.

Koenig

IRON WORKS, Inc.

P. O. BOX 7726 • HOUSTON 7, TEXAS

Barge Removes Platforms

Pictured here is a barge specially designed for Coastal Marine & Construction Corp. to set and remove drilling platforms used in offshore drilling operations. The hinged portion, which is used to lower the platform, is shown being submerged under control of four Joe Stine hydraulic rams. Horizontal locking pins in the photograph are actuated by Joe Stine cylinders. All ballast and flooding valves are controlled by Joe Stine operators.

PGAC Moves Into Mississippi And West Texas With Services

Perforating Guns Atlas Corporation has extended its Induction-Electrical and Electrical Logging services to the West Texas area, with operating headquarters at the company's Odessa office. PGAC has also extended its Laterolog and Micro-Laterolog services to the West Texas fields.

Induction-Electrical Logging services have also been extended to the Mississippi fields, with operating headquarters at the company's Laurel, Miss., station.

George Decker, formerly district manager of PGAC's South Texas district, has been transferred to the company's office at Lafayette, La., as district manager of the South Louisiana district.

Harry B. Hacke, previously district manager of PGAC's South Louisiana district, has returned to the company's Houston plant and resumed his former duties as operations superintendent and assistant to James H. Russell, manager of operations for the company.

Robert D. Tibbs, previously a sales engineer with PGAC, has been promoted to district manager of the company's Oklahoma district, with headquarters at Oklahoma City.

Western Company Relocates Fracturing, Acidizing Facilities

Installation of fracturing and acidizing station facilities of The Western Company at Liberal, Kans., has been announced. The new station is a relocation of Western's Ulysses installation.

The station move involves transfer of some 27 sales and operations personnel from Ulysses to Liberal. Dick Brammer continues as the district sales manager and Abe Butler as the district operations manager.

Deep Hole in Assumption Parish. Here's a part of a Falcon Seaboard crew working on a deep-well job in Assumption Parish, Louisiana, just a few miles north of the Gulf. When the picture was taken, they were coming out of the hole, which had reached a depth of more than 13,000 ft. Plans called for setting a string of 7⅝-in. casing, then drilling to a final depth of about three miles.

The rig was equipped with a Bethlehem rotary line, a 1¼-in. rope with tremendous reserve. It had the great strength and toughness that are always needed to handle drill pipe and casing. Bethlehem also furnished the coring line, which was shielded from moisture and gases by a heavy bethanized coating.

Bethlehem Steel Company, Bethlehem, Pa. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

Mill depots and distributors from coast to coast stock Bethlehem rope for the following industries and numerous others:

PETROLEUM • CONSTRUCTION • EXCAVATING • MINING • QUARRYING • LOGGING • MANUFACTURING

Tuloma Builders, Inc., Doubles Shop Facilities in Tulsa

Tuloma Builders, Inc., announces completion of its newly equipped pipe fabrication plant located adjacent to its main offices in Tulsa. The additional 8,000 square feet of plant area containing 10 ton crane capacity, now more than doubles Tuloma's modern code fabricating shop facilities.

Equipped with a 40 by 100 foot main bay, the new structure houses an automatic 30 KW Hobart stress-relieving machine and complete bending facilities. An extensive grounding system has been installed for producing maximum quality welds. The west end of the shop has been designed for future expansion.

Grant Oil Tool Convenes

Members of the Grant Oil Tool Company Permian Basin sales staff are shown assembled in Odessa, Texas, for their quarterly sales meeting. Shown left to right, standing are Raymond Taylor, Samuel Gleaton, Drew Johnson, Glenn Hunt, Luther Pirtle, Hobbs Branch Manager Robert Melton, Field Engineer Ken Shellman and, seated, Carl Williams, Division Manager Rex Walling, Vice President Albert Salvatori, Reater Mead, and Russell Gifford.

WHEELING

COUPLINGS

FOR OIL COUNTRY USE

LINE PIPE COUPLINGS A. P. I.
⅛" to 12"—Seamless and Special Processed Black or Galvanized
PLAIN TUBING COUPLINGS A. P. I.
1" to 4"—Seamless
EXTERNAL UPSET TUBING COUPLINGS A. P. I.
¾" to 3½"—Seamless
CASING COUPLINGS A. P. I.
4½" to 13⅜"—Long or Short
HYDRAULIC COUPLINGS
⅛" to 4"—Seamless
REAMED AND DRIFTED A. I. S. I.
¾" to 12"—Seamless
DRIVE PIPE COUPLINGS
6" to 12"—Seamless
PIPE NIPPLES
All Sizes and Types
STEEL BUSHINGS AND PLUGS
3,000 lb.

WHEELING MACHINE PRODUCTS COMPANY

WHEELING, WEST VIRGINIA

WEST COAST FACTORY: WOODLAKE, CALIFORNIA

X

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Chicago, Ill.—Harry A. Jay, Suite 1090, Old Colony Bldg.
Denver, Colo.—W. G. Cline & Co., 4500 Kalamath
Detroit, Mich.—R. W. Lang, Jr., 505 Park Avenue
Erie, Pa.—R. J. Maggi, Box 711
Falmouth, Mass.—Walter S. Bennett, 5 Belvidere Road
Grand Rapids, Mich.—R. W. Lang, Jr., 138 Burton SE
Houston, Tex.—Henry H. Paris Distributor, Inc., Box 932
Independence, Mo.—Craig A. Fross, 3701 Norwood
Long Island City, N. Y.—Max Rothenberg Co., Inc., 11-05 38th Ave.
Los Angeles, Cal.—James A. Riordan Co., 1400 Santa Fe Ave.
Louisville, Ky.—Sid Schultze Co., 849 So. 6th St.
Narberth, Pa.—Worthington-Grothaus Associates, 105 Forrest Ave.
Omaha, Nebr.—Wm. Freiden, Central States Engineering & Sales Co., 5101 Blondo St.
Oswego, N. Y.—Northeastern Associates, Neil Chatterton, Sec'y, P. O. Box 284
Portland, Ore.—J. G. Beard Co., 1233 NW 12th Ave.
Richmond, Va.—P. C. Abbott & Co., 15 E. Franklin St.
St. Louis, Mo.—Walter C. Dollinger Co., 4869 Goodfellow Ave.
Salt Lake City, Utah—Lovell Company, 29 E. 2nd St. South
Seattle, Wash.—Ashe & Jones, 819 Thomas St.
Wauwatosa, Wisc.—W. G. Nelson, P. O. Box 203

QUALITY-CONTROLLED PIPE COUPLINGS SINCE 1918

Y.P.F. of Argentina Receives Group of Unitized Drills

A group of Portadrills destined for the Y.P.F., Argentina's government-owned oil enterprise has arrived satisfactorily at the field destination.

Portadrills supplied to the Y.P.F. were of the Model BHD-C, a truck-mounted unitized drill for both air and water drilling, seismic exploration, core drilling and mineral prospecting. Mounted on International Harvester R-190 four-wheel drive trucks, the Portadrills are highly mobile and are well suited to off-road operations.

Rocky Mountain Export Company made the shipment on the S. S. Grandero, a Dodero Line vessel out of the Port of Houston.

Lounsbury Named Distributor For Bucyrus-Erie in Canada

Lounsbury Company, Ltd., Monoton, N. B., has been appointed a distributor in the province of New Brunswick for Bucyrus-Erie Co., South Milwaukee, Wis., and for its Canadian subsidiary—Bucyrus-Erie Co. of Canada, Ltd., Guelph, Ont.

Aronson Machine Co. Chooses 6 Concerns as Representatives

Six companies located throughout the country have been authorized to represent Aronson Machine Company of Arcade, N. Y. The concerns, as dealers in Aronson heavy-duty welding positioners and turning rolls are Airline Welding and Engineering Co., Hawthorne, Calif.; Texas Welding Supply Co., Dallas; Arcet Equipment Co., Richmond, Va.; Dye Oxygen Co., Inc., Phoenix, Ariz.; Kirk-Wiklund Co., Kansas City, Mo.; and R & R Welding Supply Co., Des Moines, Iowa.

Borg-Warner Opens Center For Educational Exhibits

The area, known as the Borg-Warner Exhibit Center, is the showplace for the 40 divisions and subsidiaries of the corporation. It contains animated and audience-participation exhibits showing scientific, industrial and home developments and products and services. There also will be a theater and meeting room.

A colorful, two-level industrial-educa-

tional exhibit center was opened recently in Chicago by the Borg-Warner Corporation.

F. W. Richmond Purchases Large Portion of HOMCO Stock

The purchase of a substantial block of stock in Houston Oil Field Material Co., Inc., by Frederick W. Richmond, New York industrialist, was announced by George O'Leary, president. A certain amount of the stock was made available to Richmond by some of the directors of the company.

At the same time it was announced that O'Leary, a founder of the 30-year old oil field supply and service company, will retain the post of president.

Richmond was named chairman of the board and will take an active interest in the affairs of the company.

L. Joseph Lawrence, who has been with HOMCO for 23 years, has been named executive vice president and chairman of a newly created Management committee on which will sit all of the heads of the company's operating departments. Huntingdon T. Hamm was named secretary-treasurer. He will retain the post of comptroller of the company.

Additions to the Board include: Eliot Janeway, economist and president of Janeway Publishing and Research Corporation, publisher of financial and industrial services; Horace Ford, former treasurer of Massachusetts Institute of Technology and member of the board of a number of companies; Clarke Simonds of Providence, R. I., partner in the investment firm of G. H. Walker & Company, a business consultant and also a director of a number of companies; and J. Thomas Kenneally, an associate of Richmond.

Reed Roller Bit Co. Outlines Over-all Expansion Program

A broad expansion and sales buildup program, entailing a capital outlay of $25 million over the next five years, is planned by Reed Roller Bit Company. The Houston plant of the oil tool manufacturer and distributor will receive about $20 million, approximately 80 percent.

Reed plans an over-all expansion, from machine shops, research laboratories to the sales organizations through modernization and diversification.

John F. Maher, recently elected president, has set a sales target of $50 million by June, 1961, with emphasis on domestic sales. He has stressed that Reed will build and expand rather than merge.

J. Ray McDermott Co. Moves Offshore Platform to Site

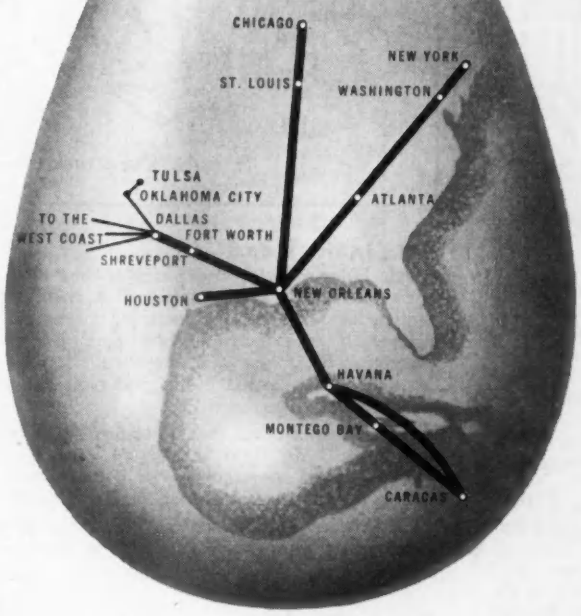
The first West Coast offshore drilling platform left the building yards of National Steel and Shipbuilding Corporation at San Diego for its drilling site off the coast of Santa Barbara recently. Built by NASSCO for Standard Oil Company of California, Western Operations, Inc., and Humble Oil and Refining Company, it will test the Summerland Offshore Lease acquired in 1957 with a bonus bid of $7,250,000 to the State of California.

Two tugs were used to move the platform to the site where it was assembled and positioned by the J. Ray McDermott Company's derrick barge No. 11. This barge, large as a football field, mounts a revolving crane having a 220 feet boom with a capacity of 250 tons.

DELTA flies where Oil is King

Royal Caribe

GOLDEN CROWN DC-7



daily through plane service between **NEW ORLEANS-CARACAS** and **HAVANA-CARACAS**

connections at New Orleans to and from all points in mid-America and the West Coast

Delta provides a luxury service catering especially to the Oil Kingdom with deluxe DC-7's daily between the U.S., Cuba and Venezuela. You're sure to enjoy the "Royal Caribe" with its special menus, choice of beverages, comfortable *air-foam* reclining seats and radar-guided "Velvet Ride." When you fly where Oil is King, fly in royal style on Delta, the choice of experienced oil men.

Serving 60 cities in the U.S.A. and the Caribbean

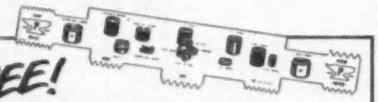
Delta AIR LINES

General Offices: Atlanta Airport, Atlanta, Georgia

For more data on advertised products, use Readers' Service Cards, last page.

Anvil Brand Couplings start clean, run up fast because threads and chamfers are precision machined, gaged throughout manufacture, and electro-galvanized. Uniform wall thickness and properly aligned sealing surfaces provide dependable mechanical strength and full joints for trouble-free string service, minimum maintenance.

Anvil Brand Fittings—A.P.I. Couplings for all oil field applications, bushings, plugs, and nipples, are sold through your nearest supply store. Engineering service is always available from Anvil Brand Representatives in key oil country locations. Write for information.



FREE!

POCKET SIZE THREAD GAGE

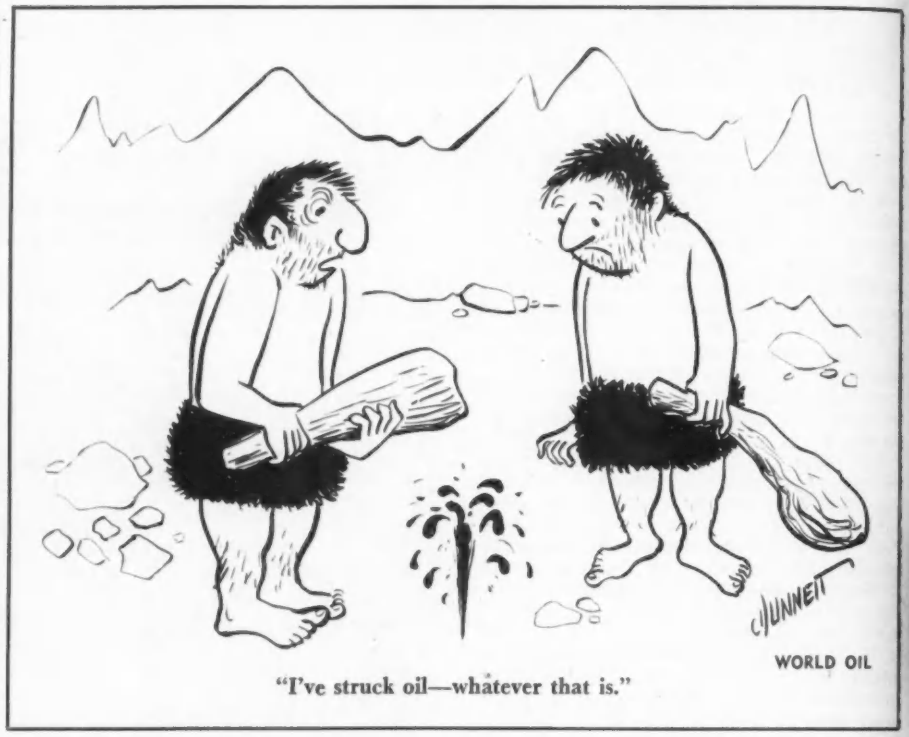
Identifies threads from 8 to 14 per inch, round or sharp, external or internal. Only 6¼" long. Write Oil Field Dept., Pittsburgh Pipe and Coupling Co., Allison Park, Pa.

ANVIL BRAND
forged seamless and wrought steel pipe fittings

PITTSBURGH
PIPE and COUPLING COMPANY
ALLISON PARK PA. U.S.A.

Subsidiary: Anvil Products, Inc., Longview, Tex.
Affiliate: Canadian Coupling and Fittings, Ltd., Simcoe, Ont.

SQUEAKS from the BULLWHEEL



"I've struck oil—whatever that is."

Pain in the Head

An elderly lady, the bane of her doctor's existence, once attended a medical lecture at the county seat. Immediately afterward, she rushed over to tell the physician that she was positive she had a rare form liver trouble mentioned by the speaker.

He brushed her aside somewhat impatiently. "My dear lady," he explained testily, "that particular condition never causes pain or discomfort of any kind."

"I knew it! I knew it!" roared the neurotic. "Those are my symptoms exactly."

Quick Thinking

A man was out with the boys one evening and before he realized it, the morning of the next day had dawned.

He rang his house and when his wife answered the phone, he shouted: "Don't pay the ransom, honey, I've escaped."

Shirking Working

Doctors doubt that hard work ever really killed anybody, but they have known cases where it seemed to scare a person half to death.

Back to the Beginning

We know that a fool and his money are soon parted, but what would be interesting to learn is how they got together in the first place.

Read Between Lines

The executive was finding it difficult to write a letter of reference for his recent assistant. Happy to see the former employe leave, he still felt he had no right to blight a budding career—nor to mislead another employer.

Finally he dictated a single sentence: "We believe this young man will go far and are pleased to have had a part in helping him get started and keeping him moving."

Once Upon a Time

The father had taken his little boy to the pet shop to pick out a puppy as a birthday present, and the lad spent half an hour looking over the assortment of pooches in the window.

"Decided which one you want?" asked his father.

"Yes," replied the boy, pointing to one pup which was wagging his tail enthusiastically, "that one with the happy ending."

SECONDARY RECOVERY
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PETROLEUM ENGINEERS
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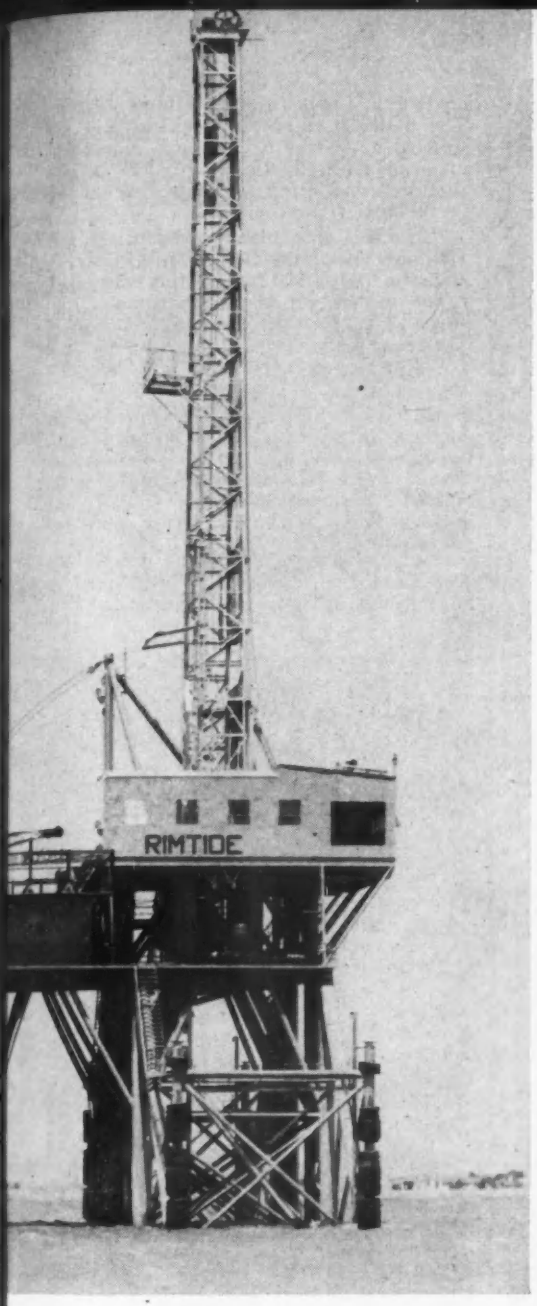


More than two years ago, Rimrock Tidelands launched a bold, new off-shore drilling program.

Dependable power was a major consideration.

To achieve versatility with maximum dependability, which is of prime importance in off-shore drilling, Rimrock's management selected Stewart & Stevenson multiple engined power packages.

Since the commissioning of Rig #3, three additional off-shore rigs have been placed in service. All four, including the mammoth new RIMTIDE which features more than 3500 horsepower, have been powered with General Motors Diesel Engines by Stewart & Stevenson Services.

If you have a power problem . . . whether it is unusual, particularly difficult or just routine . . . why not draw on the experience of the world's largest distributor of diesel engines.

STEWART & STEVENSON SERVICES, INC.

Main Office and Plant:	4516 Harrisburg Blvd., Houston 11, Texas
	Phone CApitol 5-5341
Branches:	Corpus Christi, Dallas, Lubbock, San Juan, San Antonio, Beaumont, Odessa
Representatives:	Longview, Brownsville, Wichita Falls, Freeport
Export:	Room 1405, 74 Trinity Place, New York, N. Y.

STEWART & STEVENSON

from Stewart & Stevenson

IN A ROW

3

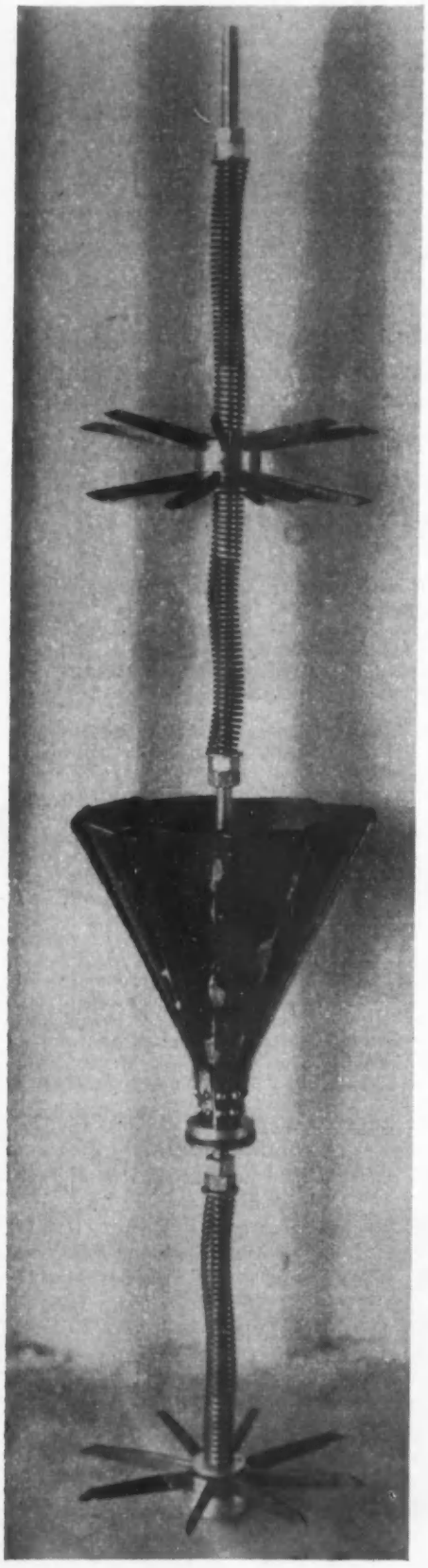
Rimrock Tidelands Rig #14 Powered by two Stewart & Stevenson S-24-2406 Quad 110 Power Units, developing 2000 combined HP. Auxiliaries consist of two S & S Model 110 GD-110, 100 KW AC Generator Sets.

4

The RIMTIDE is the newest member of the Rimrock Tidelands family of offshore drilling rigs. Powered by three Model S-24-2406 S & S model 6-110 Quads and one Model 12-2406 GM Twin 110 Diesel Engines, developing 3500 combined HP. Auxiliaries of three S & S model 110 GD-100, explosion resistant, 100 KW AC Generator Sets and one Model 6-110 GM Power Unit.

What's New in EQUIPMENT and SERVICES

Drilling - Production - Exploration



Bridging Plug

A new through tubing bridge plug has been introduced by Go Well Service. The simple, inexpensive tool used in conjunction with a dump bailer provides a unique means of setting a permanent plug in 5½ or 7-inch casing without removing tubing from the hole.

Main advantages of the tool are that no rig or pumping equipment is required, a complete plug back and reperforate job can be performed at minimum cost, tubing remains undisturbed in the hole at all times, a recording collar locater assures accurate placement of cement and bridge plug, the tool can be run through 2 and 2½-inch tubing equipped with landing nipples, by knocking off the upper set of dogs the tool is easily pushed downhole and recompletion time is reduced to a minimum.

The plug consists of a 7/16-inch O.D. threaded steel or aluminum mandrel; a spring steel metal petal basket; two sets of steel dogs (hold down and hold up) and a third set of protective dogs. Dogs are spring loaded.

The tool can be run through tubing as small as 2⅜-inch O.D. (equipped with type S landing nipples). It is set in 5½ or 7-inch casing for $275 (set up charge) plus 2 cents per foot. Cement and mixing facilities are furnished.

A truck mounted 45-foot telescoping mast is used with a perforating-logging truck to set the bridge plug.

The following procedure is used on a typical job:

A gage run is made with a 1½-inch O.D. recording collar locater and an empty 10-foot section of dump bailer. Old perforations, collars and fluid level are checked for correlation purposes. If required, a through tubing gamma ray neutron survey can be run at this time.

The bridge plug is run on 3/16 or 5/16-inch electric line. The top two-thirds portion of the plug is encased in a 1¾-inch O.D. shoe. The lower most set of dogs is exposed but held in a retracted position by a 1/32-inch steel line equipped with an electric squib. Collars are checked, and the tool is positioned at the desired spot in the well.

After positioning, the electric squib (blasting cap) is fired, severing the 1/32-inch steel retaining wire and releasing the bottom set of dogs which engaged the wall of the casing.

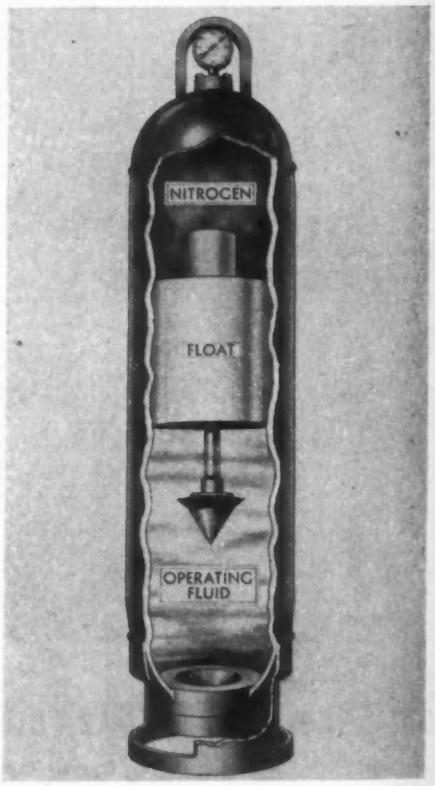
The retaining shoe snugly fits the top portion of the bridge plug. Pulling the shoe free "sets" the lower dogs and allows the metal petal basket, top dogs and protective dogs to expand. As much as 600 pounds weight can be set safely on the protective dogs to effectively seat the top retaining dogs. In case of emergency, the plugs can be knocked free with the running tools.

A dump bailer (1¾-inch and 1⅝-inch O.D. bailers are available) is used to deposit cement on top of the bridge plug. The bailer is equipped with a brittle aluminum bottom. A blasting cap suspended on a plumb bob is positioned immediately above the aluminum bottom. The bailer is filled with cement and positioned above the bridge plug. The blasting cap is fired, the aluminum bottom shattered and cement is deposited on top of the tool from the bailer.

Capacities of available dump bailers are: 100-foot section—1¾-inch O.D.—1½ sacks per trip; 100-foot section—1⅝-inch O.D.—1 sack per trip. The company anticipates running as much as 200 feet of 1¾-inch bailer in 2½-inch tubing and 200 feet of 1⅝-inch bailer in 2-inch tubing.

Go is considering squeezing by the method in the future. A bradenhead squeeze will be imposed on a column of cement resting on the plug (which is set below the perforations). Following the squeeze excess cement will be chipped out by wireline tools.

For more data, circle **No. E1** on Readers' Service Card, last page this issue.



Non-Separator Accumulator

This Payne Manufacturing Company accumulator is built especially for installations where high discharge velocity is a requirement. When used in pump desurger service, it fills a pressing need for a reliable unit to soften destructive power impulses. As in other Payne non-separator type accumulators, a free moving float takes the place of rubber bladders or diaphragms.

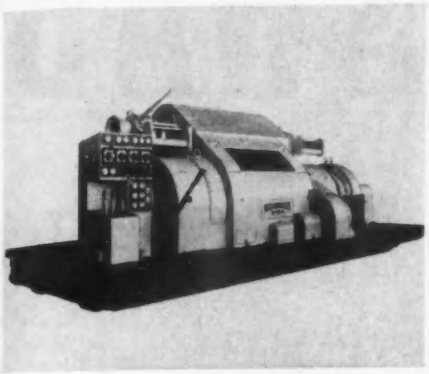
This model uses an oversize removable shutoff valve which seats first on a Hycar rubber element and then effects a metal to metal secondary seal. Nitrogen precharge is positively retained, and there is no vortex effect. Valve replacement, when necessary, is easy and inexpensive.

Sizes range from 1 to 20 gallons with working pressures from 2,000 to 6,000 psi. Any volume is available with multiple units. Standard models will handle a variety of fluids, including water, oil, distillate, mud and certain chemicals. Ac-

cumulators made of special materials for other fluids are available.

(This item supplements Payne Manufacturing Co. data on Pages 4277-4296 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E2** on Readers' Service Card, last page this issue.



Medium Depth Drawworks

Faster and more efficient drilling is the outstanding feature of an all-new drawworks, the U-712-A, being offered by Mid-Continent Supply Co. Operating controls have been incorporated into a new single console, increasing the efficiency of the driller.

This centrally-located panel equipped with speed selection levers and air actuated clutch controls provide complete control of the rig by the driller with a minimum of effort. The U-712-A, manufactured by Unit Rig & Equipment Company, is designed for medium depth drilling in the 8,000 to 12,000 foot range.

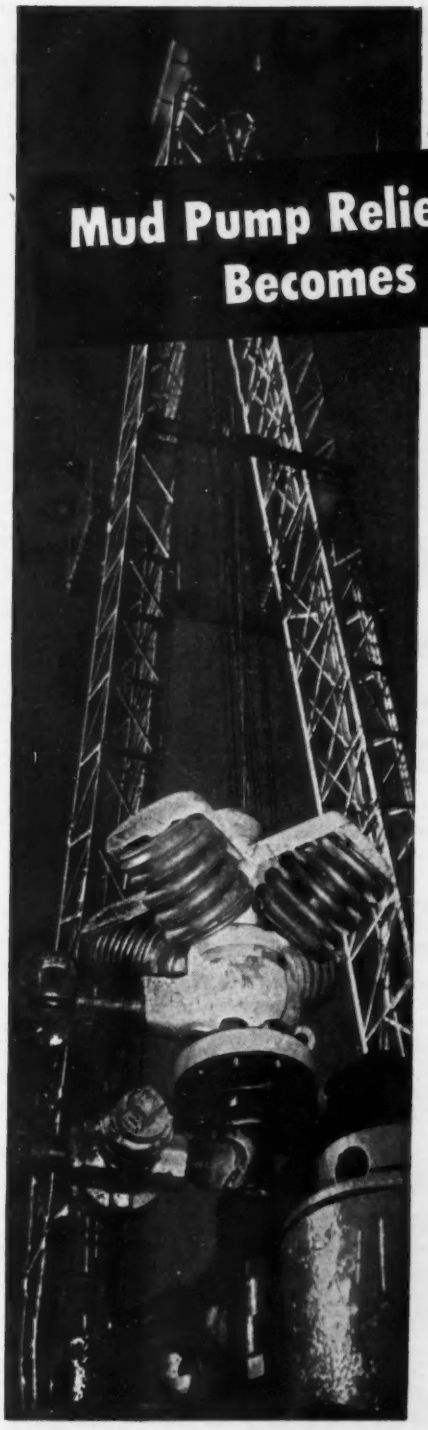
(This item supplements Mid-Continent Supply Co. data on Pages 3425-3472 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E3** on Readers' Service Card, last page this issue.

Chain Tong Line

Introduction of a new and rugged line of chain tongs and spinning and cathead chains has been announced by the Chain division of Bettis Corporation. Both products have been trade-named Trojan.

Trojan chain tongs are of the same design as other regular single end chain tongs. The jaws are drop-forged of high quality steel, hardened and tempered to



Mud Pump Relief Valve Importance Becomes More Critical

As mud pumps are necessarily operated at near capacity to meet the constantly increasing demands on drilling circulating systems, the safety demands on the relief valve become greater.

Responsibility for reducing hazards of personal injury, equipment damage and drilling trouble by relief of excessive drilling mud pressures, calls for a valve that assures positive instantaneous pressure relief at maximum volume and automatic restoration of circulation upon correction of the overloading condition. These requirements have been accomplished in the Kinzbach Model 112 Pressure Relief Valve by combining two unique methods of restraining the valve piston, yielding a characteristic action from a decreasing force against the valve piston on opening movement, and conversely, an increasing force during closure. This assures higher effective lift during valve action.

When excessive circulating pressures occur, the valve either repeats its cycle of rapid opening and closing, or remains open until the obstruction is removed or the pump stopped. Momentary blocks do not require pump shutdown to reset the valve. Movement of fluid may not be materially affected, preventing danger of stuck drill pipe as might occur with arrested circulation. Compounding Heads are available where pumps are used in series.

Kinzbach Model 112 Pressure Relief Valves are available in 2" and 3" sizes with pressures ranging from 500 psi to 16,500 psi. Write for complete data or consult your new Composite Catalog. Sold through Supply Stores everywhere.

KINZBACH TOOL CO INC

KINZBACH TOOL COMPANY, INC.

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EXPORT OFFICE: 74 TRINITY PLACE, NEW YORK, N. Y.

DARCOVA
now offers...

- MORE STRENGTH
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with 100% NYLON COMPOSITION!

Darcova Valve Cup

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Darcova Seating Cup

Darcova 45° Bevel Cup

and *only* in DARCOVA can you get this time-saving, money-saving advantage! Available in the full range of sizes and Darcova textures for varying well conditions.

Send for Bulletin No. 5502 and specify DARCOVA at your supply store. There *is* no substitute!

DARLING VALVE & MANUFACTURING COMPANY

DARCOVA ®

WILLIAMSPORT 28, PA.

THE ORIGINAL COMPOSITION CUP

perfection to insure longer wear. Chains and pins also are of high quality steel and in addition are heat-treated to make them stronger and safer.

(This item supplements Bettis Corp. data on Page 693 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E4** on Readers' Service Card, last page this issue.

Solid Thimble

A new solid wire rope thimble with large radius to minimize rope bending is now offered for use with open sockets, wedge sockets and the new Crosby-Laughlin boom pendant clevis.

A steel casting, the new thimble is available for all sizes of wire rope, from ½ to 1⅜-inch, for use with pins from 1 to 2½ inches in diameter.

(This item supplements Crosby-Laughlin Division, American Hoist & Derrick Co. data on Pages 1414-1415 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E5** on Readers' Service Card, last page this issue.

Redwood Fiber in Mud

Introduction of 100 percent redwood bark fiber as the exclusive ingredient in Palco Seal drilling mud loss circulation material, available in 40 pound multiwall bags, has been announced by The Pacific Lumber Company.

The combination of large and small fibers forms a particularly dense matted barrier in a wide range of porous and thief formations. Redwood bark fibers mix readily with muds, remain consistently in suspension and pump easily. The material

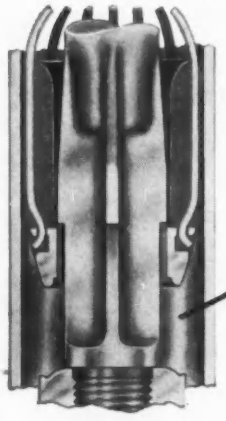
Join the thousands using

THE OIL STATES

SWAB

... that sets the Standard for Industry

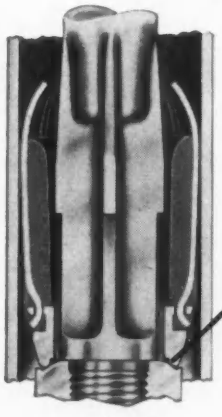
✻ Only SIX PARTS required



✻ Perfect for sanding conditions

Note adequate flow through passage.

✻ Unrestrained tops . . . respond to lightest or heaviest loads



✻ Positive valving with each cup

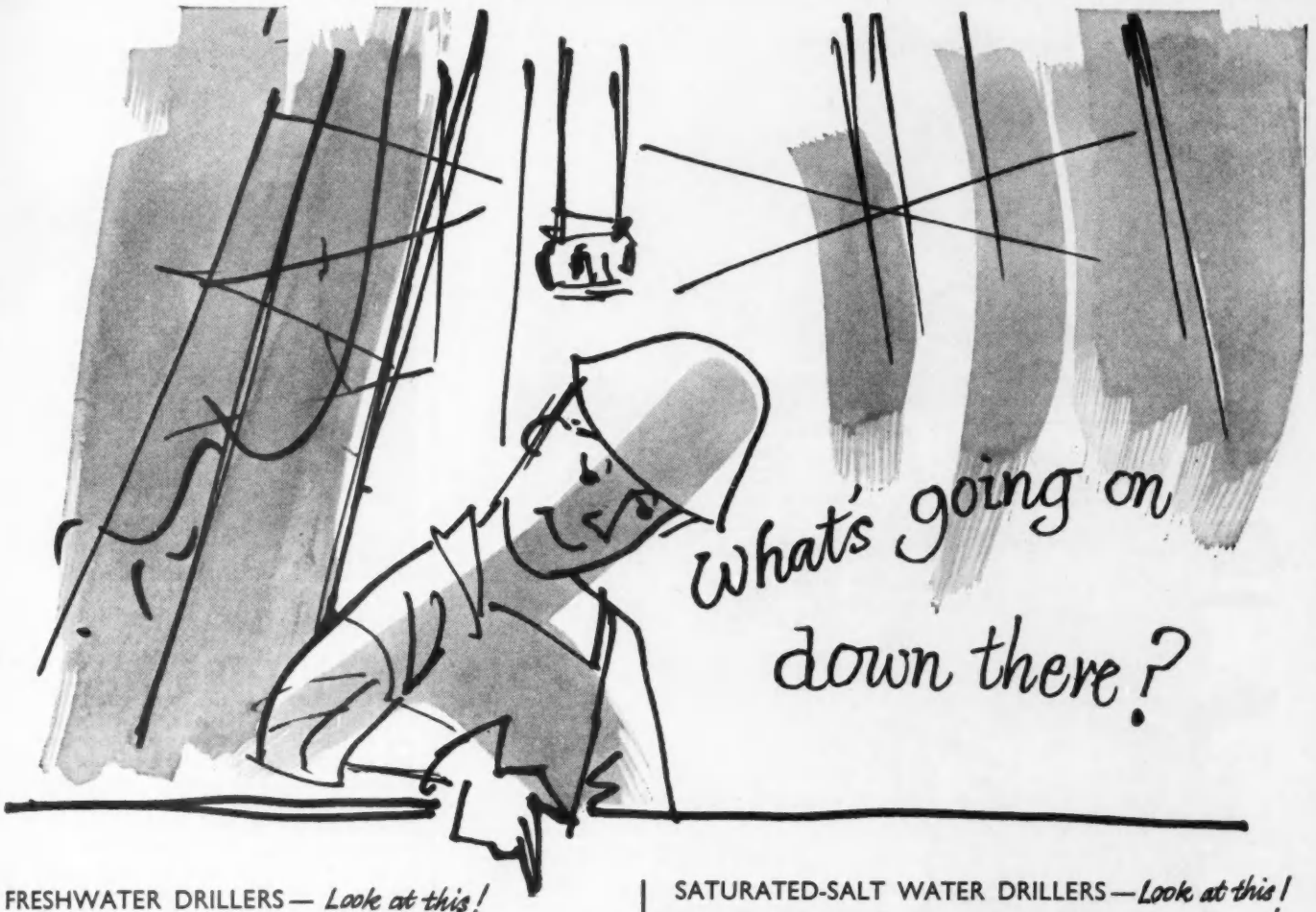
Cup in closed position showing rubber impinged seal.

✻ No ball and seat to wear

Sold through Supply Stores Everywhere

Oil States

OIL STATES RUBBER CO.
Arlington, Texas



FRESHWATER DRILLERS— *Look at this!*

6% Bentonite 11 cp. mud, plus **'KIRKOSE'** *addition.*

Lbs. per Barrel 'KIRKOSE'	*Fann Viscosity cps. (600 r.p.m.)*	*Gel strength lbs/100 sq.ft. 0/10 mins.*	*Fluid Loss API mls 100 psi/ 30 mins.*	*Cake Thickness 1/32"*
0	11	0/15	26.0	3
½	8½	0/12	10.2	1
¾	8	0/12	8.2	1
1	9	0/12	8.0	1
1½	12½	0/16	7.6	1
2	15½	0/18	7.4	1
3	22	0/18	6.6	1

¾ to 1 lb. per barrel slashes fluid loss without raising viscosity or Gel Strength!

Non-fermenting; no antiseptic needed.

SATURATED-SALT WATER DRILLERS—*Look at this!*

6% Attapulgite 12 cp. mud, in saturated brine, plus 'KIRKOSE' addition.

Lbs. per Barrel 'KIRKOSE'	*Fann Viscosity cps. (600 r.p.m.)*	*Gel strength lbs/100 sq.ft. 0/10 mins.*	*Fluid Loss API mls 100 psi/ 30 mins.*	*Cake Thickness 1/32"*
0	12	0/0	125.0	7
1	8	0/0	52.0	5
2	7	0/0	26.4	3
3	9½	0/0	15.0	2
4	15½	0/0	8.7	1
6	35	0/0	4.5	1
8	65	0/0	2.9	1

4 lbs. per barrel turns a tough assignment into a workable job.

7-8 lbs. per barrel gives lowest fluid losses, still within the limits of possible mud viscosity.

Salt-mud with Attapulgite plus 'KIRKOSE' *is the answer to heaving shale problems! For highest yield and efficiency choose* 'ATTAPULGITE SWS' *by Minerals and Chemicals Corporation of America, Menlo Park, N.J., U.S.A.*

Kirkose

THE WORLD'S FIRST TECHNICAL GRADE C.M.C.
SUITABLE FOR ALL DRILLING APPLICATIONS, SALT AND FRESHWATER ALIKE SOLD AT TECHNICAL GRADE PRICES

CABLE "KIRKSYL" BURY, ENGLAND, FOR BROCHURE OR SAMPLE.

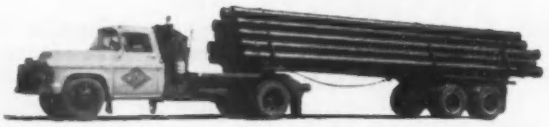
Issued by the Chemical Division of KIRKLEES LTD., BURY, ENGLAND

Congrats and $25 to Doug Foster, Atlantic Refining Co., Dallas, Texas

Drilling for and producing oil and gas is a rugged business demanding great risk and courage. More, it requires plenty of rugged, dependable pipe. That's why Lone Star Steel was established in the heart of oil country.

The huge Lone Star plant, a modern miracle of automation and quality control, makes the kind of tough casing, tubing and line pipe American Petroleum Institute specifications call for. And, as Joe Roughneck knows, Lone Star offers a real convenience in fast, economical delivery.

Neighbor, wherever you are, specify Lone Star and we both get a good deal.



©1956 Lone Star Steel Company

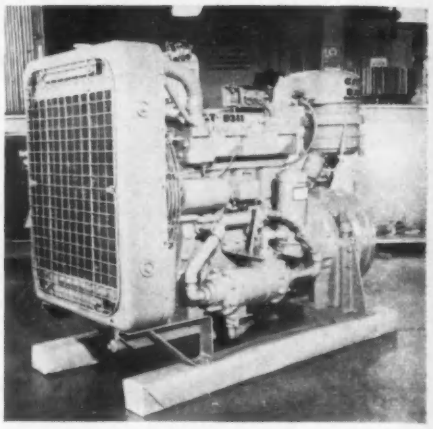
Lone Star STEEL

COMPANY

EXECUTIVE—SALES OFFICES
W. Mockingbird Lane at Roper • P. O. Box 12226 • Dallas, Texas
DISTRICT SALES OFFICES
912 Republic National Bank Building, Dallas, Texas
Houston, Texas | Midland, Texas | Tulsa, Oklahoma

displays virtually complete resistance to any form of deterioration and fermentation.

For more data, circle **No. E6** on Readers' Service Card, last page this issue.



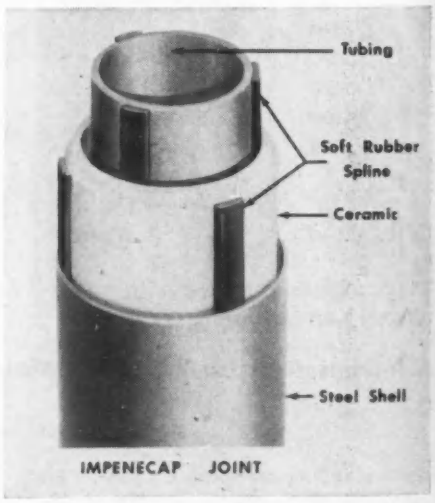
Diesel Engine

Another new diesel engine has been announced by Caterpillar Tractor Co. Engine division. It is the four-cylinder D311 (Series H). This modern, heavy-duty unit has a 4-inch bore and a 5½-inch stroke. It's a four-cycle, naturally aspirated, valve-in-head model and employs the same precombustion chamber type design used on all Cat diesel engines.

The 252 cubic inch displacement engine develops 75 horsepower at 2,400 rpm. It has an intermittent output rating of 68 horsepower and a continuous rating of 50 hp at 2,000 rpm. The generator for use with this engine has a 30 kw continuous rating and is completely self-regulated.

(This item supplements Caterpillar Tractor Co. data on Pages 1210-1212 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E7** on Readers' Service Card, last page this issue.



IMPENECAP JOINT

Protective Joint

Costly tubing replacement due to high pressure gas-jetting opposite perforations in multiple completions is said to be virtually eliminated by a new protective joint, called Impenecap, manufactured by Plastic Applicators, Inc. Comparative tests report tubing life up to 25 times greater than that provided by other types of abrasion-resistant coatings now in use. Among materials tested were natural and synthetic

A Killer Driller –

ACC
Shark Tooth
"DELTA"
DIAMOND DRILL BITS

The Shark Tooth "Delta" diamond drill bit fulfills the demand for a rugged, highly adaptable drill bit with special features designed for difficult hole conditions and rough drilling.

The cut-away feature on the circumference permits large cuttings and broken pieces of rock to clear the bit when drilling highly fractured formations and in caving holes, and facilitates washing to bottom when sluffing conditions prevail.

Oversize central discharge ports carry exceptionally large volumes of circulating fluids and handle high viscosity, heavy weight muds with minimum pressure drop. Cut-away feature eliminates back pressure between bit and hole wall. Shape of ports eliminate plugging by lost circulation material. "Deltas" should be run with relatively high circulation rates for best performance.

A larger than normal amount of fluid is diverted across the wings to increase cuttings removal and reduce dangerous over-heating.

Reducing the width of the maximum diameter, with decreased cross-sectional area, substantially reduces the danger of drill string sticking on bottom or when tripping in bad holes, ir irregular holes, at key seats, and in sections of thick wall cake build-up. It also reduces swabbing action and pressure surges when tripping.

Deliberately increasing the height of O.D. gauge surface provides extra reaming surface, compensates for reduced circumference, and stabilizes tendency to "walk" or run eccentrically. Shark Tooth "Delta" bits hold gauge longer than other similar shaped bits.

For any diamond drilling situation that involves unusual conditions, the Shark Tooth "Delta" will meet all requirements. "Delta" is available in all standard sizes and special designs for hard, medium, or soft formations.

HILLMAC

509 South Loraine Street, Midland, Texas

In Canada
COREWELL
11631-105th Avenue
Edmonton, Alberta, Canada

In South America
N. E. YETT & ASSOCIATES
Apartado 304
Maracaibo, Venezuela

ACC
AMERICAN COLDSET CORPORATION
U. S. Highway 46 Teterboro, N. J.

rubbers, PVC, plastic and glass fiber and hard lead sheathing.

The material—an extremely dense, silica-base ceramic composition—is harder than topaz, corundum or sapphire. Its method of application—designed to protect the ceramic against breakage during and after run-in—employs a steel outer shell with soft rubber splines between tubing, ceramic and shell. In effect, the ceramic floats on a cushion of rubber between two surfaces of steel, effectively protected against impact and isolated from vibration and shock.

For more data, circle **No. E8** on Readers' Service Card, last page this issue.

Composite Christmas Tree

Pictured is a single string solid block tree valve with swabbing valve, choke and flow line valve, plus gin pole socket and small threaded outlets for pressure control equipment and sampling.

The design of this composite christmas tree was developed by Cameron Iron Works, Inc., with suggestions and help from companies associated in the Royal Dutch Shell group. Trees of this type take up only 20 percent of the space required by conventional trees of the same pressure rating and size. They provide 10 percent more flow way because of the oversize bore feature.

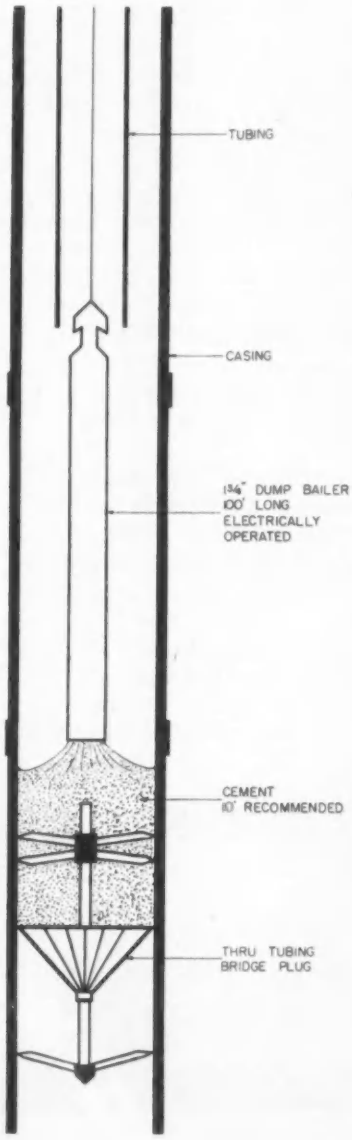
Incorporated in this design is a gin pole socket which can be used for maintenance purposes on installation. The tree is so compact that it can be covered completely by a slip-on cover, which reduces materially possible damage due to collision on Lake Maracaibo. The design also makes it possible for the flow line to parallel the casing down to a depth in the lake which will give ample ship clearance and an added safety feature.

(This item supplements Cameron Iron Works, Inc., data on Pages 1141-1200-H of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E9** on Readers' Service Card, last page this issue.

Cut Re-completion Costs in ½

with *GO* Thru-Tubing Bridge Plug and *GO* Perforating Service

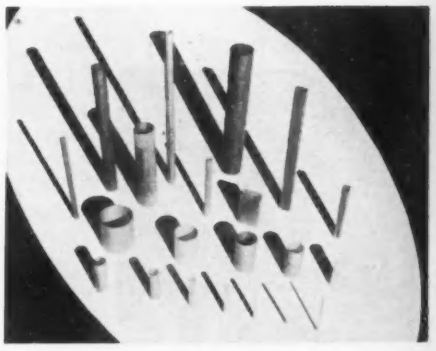


Run through 2" tubing on a conventional perforating line, the GO Thru-Tubing Bridge Plug can be set at the exact point desired in 5½ or 7" casing. No tubing extensions required . . . no need to pull tubing . . . cement is dumped on plug with a thru-tubing dump bailer. Only requirement is that the well be in a static condition at the time plug is set. As a further advantage, use of the GO portable mast eliminates need for a service unit or rig over the well.

Typical Example of Savings Possible:

A GO Thru-Tubing Bridge Plug was set through 2" tubing in 5½" casing at 10,050 feet for a major oil company on the Gulf Coast. 24 hours after running cement, new zone was perforated with 32 shots. Total cost of complete job: $844.32. Operator estimated that the same job would have cost at least twice this amount using conventional re-completion method under the most ideal conditions.

GO OIL WELL SERVICES, INC.
P. O. Box 1936
Fort Worth, Texas
Phone WAlnut 6-0273



Fiberglass-Epoxy Tubing

Lamtex Industries, Inc., has recently introduced its new Tuff-Tube laminated fiberglass-epoxy tubing.

Tuff-Tube is produced by an exclusive method of pressure and vacuum impregnation and a carefully controlled temperature curing procedure. It is a continuous weave, homogeneous laminate—no seams, dry spots, spalls, porosity or bubbles. It has smooth walls and near-perfect concentricity throughout length. It is available in almost any cross-section shape (round, square, oval etc.) in sizes from .062 inches to 6 inches ID; tubing walls as thin as .008 inches; produced in lengths up to 9 feet.

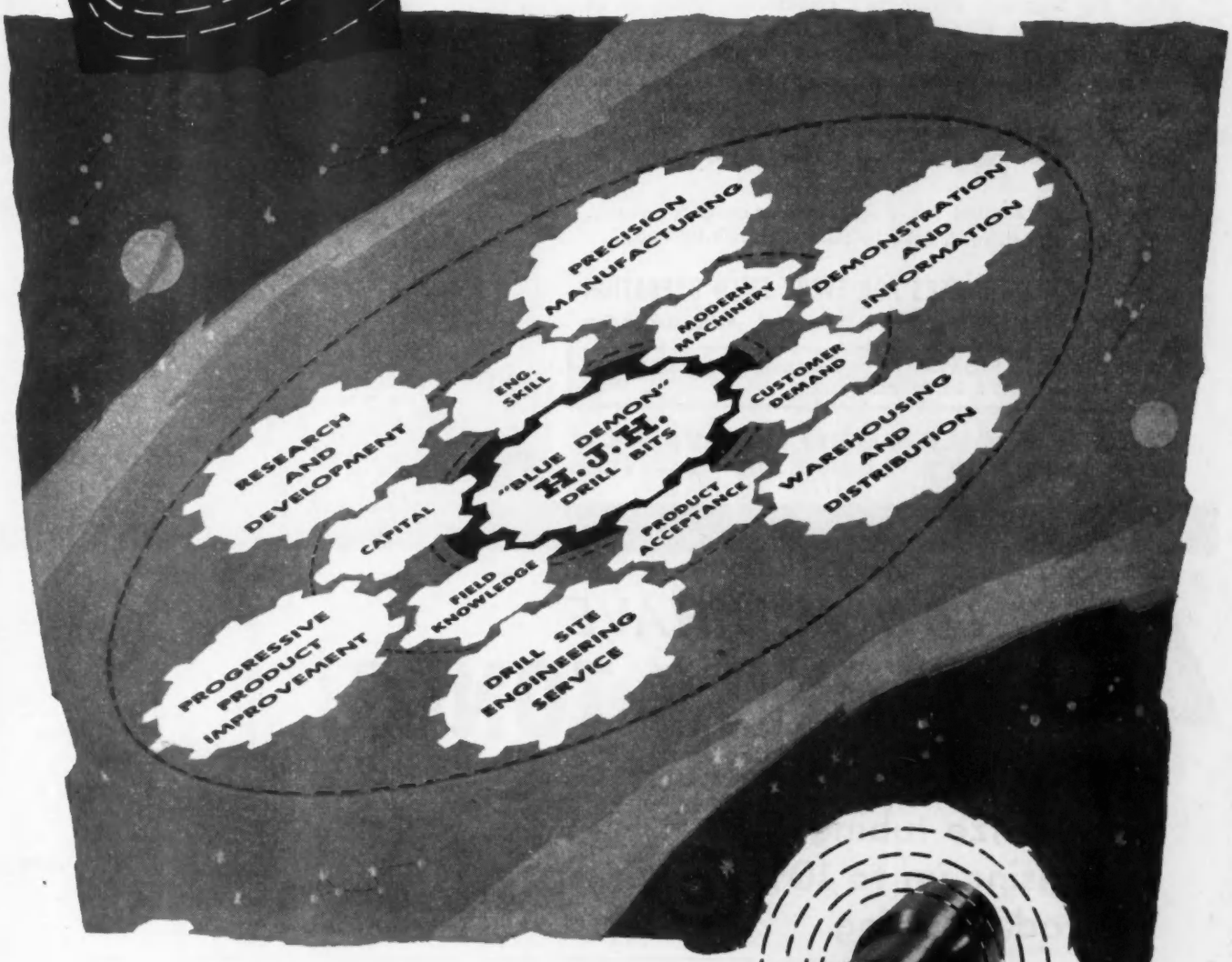
For more data, circle **No. E10** on Readers' Service Card, last page this issue.

Forged Needle Valves

A new line of general purpose, forged needle valves for 10,000 psi service has been marketed by Hoke, Incorporated. These new Series 100 valves include several innovations in design and are guaranteed leak-proof through the packing from non-critical vacuum to 10,000 psi (WOG) service.

Among the unique features of the Hoke

. . . geared for greater shot hole drilling progress in the International Geophysical Year



These gears turning to the right keep your kelly rotating smoothly for faster, more efficient drilling . . . cleaner, more economical hole. The intangible differences which keep Hawthorne leading the way in exploration drill bits.

U. S. Patents
2,615,684
2,666,622
Others Pending

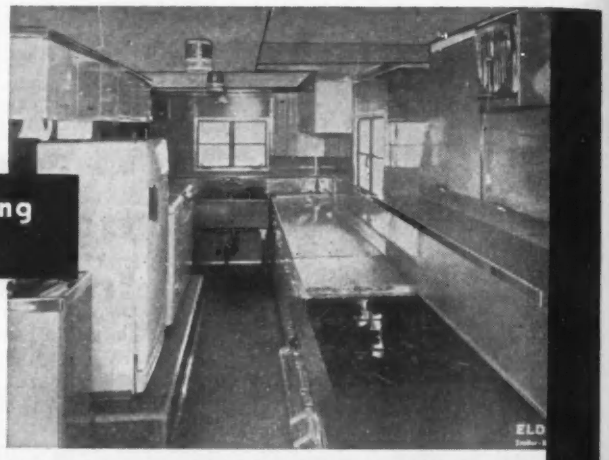
HERB J. HAWTHORNE INC.

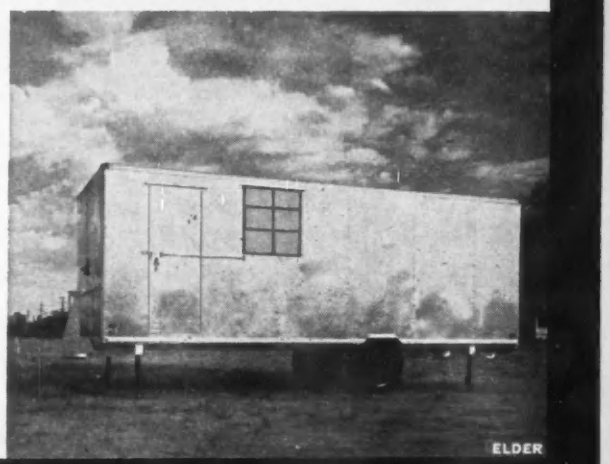
P. O. Box 7366, Houston 8, Texas

Cable Address: HAWBIT

Elder FIELD TRAILERS

Designed *Specifically* for Field Crews Operating in Remote Locations





Elder trailers are *not* house trailers . . . they are rugged field trailers, designed and built to give long, trouble-free service under the toughest, off-the-road conditions—especially in foreign countries. Equipped with large sand tires, air conditioning, rugged steel frame, light-weight aluminum body.

IMPORTANT! Elder's special lease plan saves you time and money. You need no capitol investment in trailers, and your *leased trailers are chargeable to expense!* You have no maintenance costs, no time-consuming paper work to worry about.

TURNKEY OPERATION! We'll operate your camp for you . . . furnish personnel, food, fuel, laundry and pick-up truck.

QUALITY BUILT TRAILERS FOR EVERY FIELD OPERATION

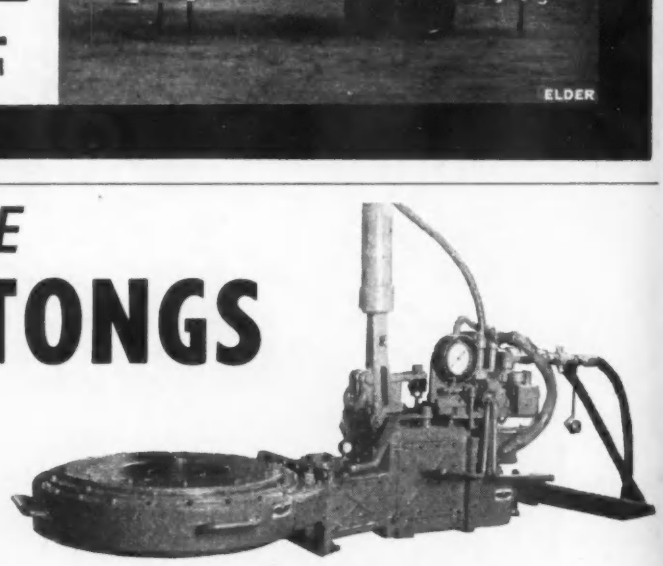
Kitchen, Diner, Sleeper, Shower, Office, Power Plant, Water Tank trailers

ELDER OIL FIELD FLOAT—SPECIAL RUNNING GEAR, LARGE SAND TIRES, HEAVY DUTY PLATFORM.

ELDER TRAILER AND BODY, INC.

P. O. BOX 9042 4830 RACE ST. DENVER 16, COLO. AMherst 6-1781

4 NOW YOU HAVE Foster POWER TONGS TO CHOOSE FROM



for all size tubing
for casing up to 10¾"
for rod stripping

- Timken Bearings in rotary head
- Pressure Oil Bath
- Improved case seal
- Roller chain final drive
- Hydraulic lift or counterweight
- Gasoline, gas, or diesel engine
- Trailer mounted, skid mounted, or truck mounted
- May be adapted to rig's hydraulic system

Model No.	Size Range	Torque range in foot pounds
54	2⅜ to 7 inch	300 to 9,000
55	3½ to 10¾ inch	500 to 15,000
57	3½ to 10¾ inch	300 to 800
58	1½ to 5½ inch	300 to 4,000

All Foster Representatives carry a complete inventory of spare parts for Foster tongs and all models of Foster Catheads.

Foster CATHEAD COMPANY
P. O. BOX 1351 WICHITA FALLS, TEXAS
2101 GRANT ST. PHONE 322-8653

SOLD AND SERVICED BY

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Peck Sales & Service . . . . . Houston, Texas
Tillery & Parks . . . . . Odessa, Texas
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R. D. Cloninger . . . . . Lafayette, Louisiana
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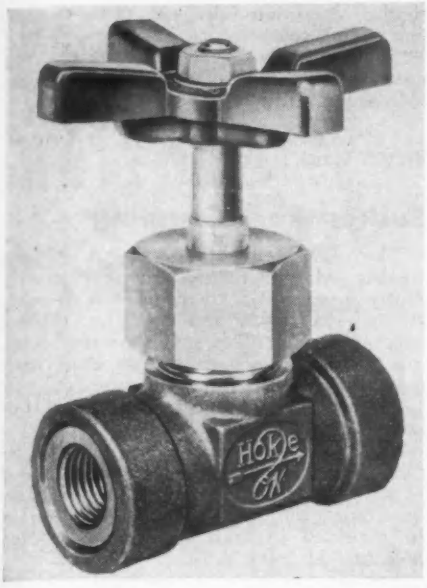
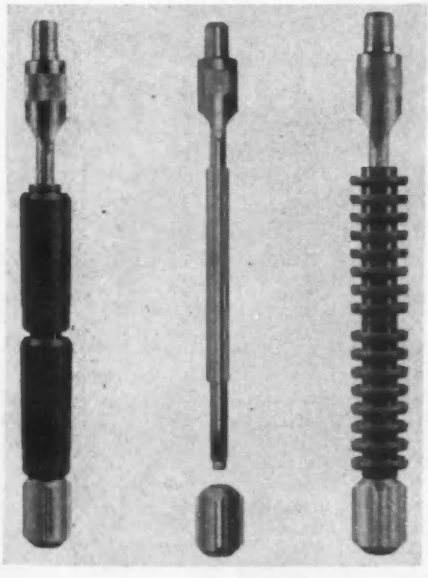
W. O. Nelson . . . . . Farmington, New Mexico
Coastal Engineering Co
Bakersfield and Long Beach, California
Moore Sales & Service Company . . Casper, Wyoming
Joe Perry . . . . . Salem, Illinois
T. C. McDonald . . . . . Shreveport, La.
Leidecker Tool Co. Ltd. . . Edmonton, Alberta, Canada
Langley Y Cia Srl . . . . . Buenos Aires, Argentina
East-West Oil Tools, C. A.
Maracaibo & Anaco, Venezuela



Series 100 valves is a Nylon stem wiper that adds materially to the life of the valve's leak-proof O-ring stem seal, as well as preventing foreign matter from scratching or pitting the centerless ground stem, thus guarding against leakage at high pressures.

Other features of the valve include a safe, integral bonnet; forged carbon steel bodies in angle or globe patterns with a selection of male or female connections and panel mounting.

For more data, circle **No. E11** on Readers' Service Card, last page this issue.



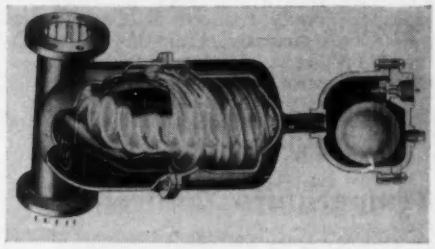
Tubing Swabs

A new line of tubing swabs is announced by Byron Jackson Tools, Inc., a subsidiary of Borg-Warner Corporation.

The new swab line features both cup-type rubbers and the multi-disc type. A pair of either kind fits onto the streamlined two-piece body. The rubbers are designed for extreme flexibility of operation; they automatically adjust themselves to different loads. This means that for a particular tubing size an operator needs but one of the compact BJ swab bodies and a pair of each of the two types of rubbers, and he is fully equipped to handle any kind of tubing swabbing job that comes his way.

(This item supplements Borg-Warner Corp. data on Pages 973-1108 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E12** on Readers' Service Card, last page this issue.



Separator

Wright-Austin Company announced its improved Type "T" separator to further its entrainment removal efficiency.

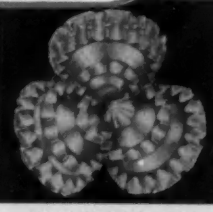
The improved Type T, designed for steam, air and gas applications, utilizes centrifugal force to separate moisture and oil entrained in the vapor flow. As shown in the illustration, the steam, air or gas is directed through an annular passage which increases its speed to produce a maximum of centrifugal force. The entrained matter which now clings to the outer wall drains to the bottom of the separator and then to an automatic trap. The entrance to the outlet chamber has been enlarged to pro-

HARD
MEDIUM
SOFT

DESIGNED AND ENGINEERED FOR FASTER ROTARY DRILLING . . .

WILLIAMS HoleMaker air and water rock bits utilize air or water to cool, lubricate and clean bearings for faster, more economical rotary drilling. A complete range of sizes from 2 15/16" to 7 7/8" comprises various tooth designs to drill more footage at a faster rate of penetration.

Williams HoleMaker ROCK BITS



WILLIAMS HoleMakers are uniform . . . batch after batch. Consistency and highest quality are guaranteed through heat treating in newest automatic furnaces. All teeth are tungsten tipped. The anti-friction HoleMaker is smoothest running, freest cutting. Rigid inspection in every manufacturing stage insures constant uniformity and quality . . . WILLIAMS standards for 2 generations.

CONTACT

J & D BIT COMPANY
P. O. BOX 608, SOMERSET, PA.

ROTARY DRILLING EQUIPMENT, INC.
221 W. OLIVE ST., SCRANTON, PA.

MANUFACTURED BY
OIL TOOL
MANUFACTURING CO., INC.
P. O. DRAWER 24
TONKAWA, OKLAHOMA
TELEPHONE: 143

For more data on advertised products, use Readers' Service Cards, last page.

vide for greatly reduced velocity at that point. This virtually eliminates re-entrainment problems associated with conventional separator designs.

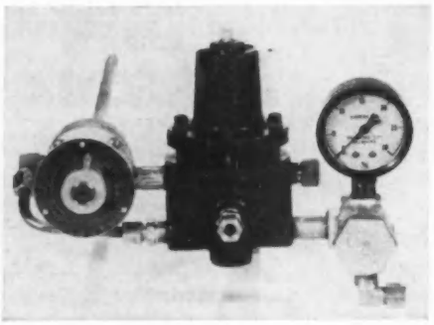
For more data, circle **No. E13** on Readers' Service Card, last page this issue.

Temperature Controller

Kimray, Inc., announced a new model temperature controller for throttling control-direct acting. The TDA is available in two models; the T-12-TDA with a 12-inch sensing element and the T-18-TDA having an 18-inch sensing element (both bimetallic).

The T-12-TDA delivers two pounds output pressure per degree F. temperature increase within the 30 pound supply pressure. The more sensitive T-18-TDA under similar conditions delivers three pounds per degree temperature increase.

(This item supplements Kimray, Inc., data on Page 2845 of the Composite Catalog, 22nd Edition.)



For more data, circle **No. E14** on Readers' Service Card, last page this issue.

Sucker Rod Coupling

The Engineering department of the Axelson Manufacturing Company has recently developed a corrosion and wear resistant API sucker rod coupling. With a friction coefficient of 0.10, the new Axelson coupling far overshadows hard steel, 0.40, and reduced force (or wear) will result in proportionately lower wear in both coupling and tubing.

Tests run by Axelson show a wear reduction of two to one in wells with low water production, and more substantial reduction in tubing and coupling wear may be expected in high water cut, crooked hole and abrasive wells.

Special oxygen-acetylene guns are used to drive the molten, tri-metal, spray hardfacing onto the coupling surface. The entire assembly is then fused at a temperature of 1,925° F., at which point the metal particles form a molecular bond with the base metal.

(This item supplements Axelson Manufacturing Co., Division of U. S. Industries, Inc., data on Pages 371-374 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E15** on Readers' Service Card, last page this issue.

BRITISH H-E MADE

300 P.A. TRACTOR DRILLMASTER

MULTI-PURPOSE · HIGHLY MOBILE

The Hands-England Drillmaster 300 P.A. Rotary Drill is now available mounted on a Fordson Major Tractor and is illustrated on left.

This design provides great manoeuvrability and is intended primarily to enable the well known H-E Drillmaster 300 P.A. Rotary Drill to be used for Quarry and Open Cast blast or shot holes.

Although the H-E Drillmaster 300 P.A. mounted on a diesel engined tractor, is ideal for Quarry and Open Cast operations, it is equally applicable to some difficult "off the road" locations, such as may be encountered during seismic exploration particularly in highly cultivated areas.

An air compressor giving 99 C F M can be mounted directly onto the drill subframe and driven from the tractor engine. This compressor gives an up-hole annular velocity of 3,000 ft./min. when using flush jointed drill pipe and holes of the following sizes:

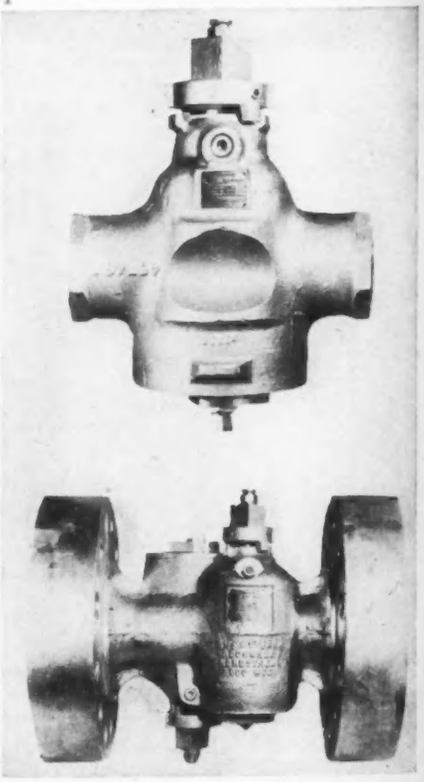
1⅝" o/d.	Drill Pipe	2⅞"	dia. hole
1.29/32"	"	3⅛"	"
2⅜"	"	3⅜"	"
2⅞"	"	3¾"	"

Larger holes or holes drilled with mud circulation can of course be drilled, but the equipment for these operations must be mounted on a separate trailer or tractor.

The H-E Tractor Drillmaster will be found to cover the majority of drilling requirements of the Quarry and Open Cast operator, the Geologist, the Mineralogist, and the Geophysicist.

Write for illustrated folders giving full details and specifications of this equipment.

HANDS - ENGLAND OILFIELD EQUIPMENT LTD
MANUFACTURERS OF GEOPHYSICAL SUPPLIES
LETCHWORTH HERTS ENGLAND TEL: 600 CABLES: OIL LETCHWORTH ENGLAND
Exclusive licensees in Western Germany: August Goettker Flachbotrungen, 20a Wathlingen Kreis Celle, West. Germany

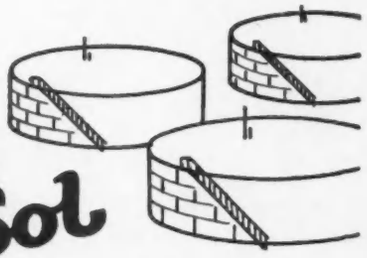


Dual Completion Valves

A new line of Hypreseal dual completion and recessed body valves—used primarily on christmas tree installations for dual-producing zones—are now available from Rockwell Manufacturing Company.

The new valves embody the basic Rockwell-Nordstrom valve principles of pressure lubrication and "Sealdport" grooving

RECLAIM TANK BOTTOMS with BrakeSol



the most effective chemical for treating

PARAFFIN

The money you make on reclaimed tank bottoms by using BRAKESOL will be substantially more than the cost of treating . . . including chemical and labor. Safe for use in production, pipeline and refinery equipment . . . Contains no chlorides, sulphides or other halides.
BRAKESOL Treating Engineers have the experience and know-how to do a successful job. Contact them now!

Treating Engineers Available at These Locations

Ardmore, Okla. 6489
Carmi, Illinois 5948
Ft. Morgan, Colo. UN 7-2235
Houston, Texas HO 5-6648
Kilgore, Texas 3210
Lovington, N. M. 6-6881
New Iberia, La. EM 4-0361
Odessa, Texas
Pratt, Kansas GR 2-3745
Edmonton, Alberta 66-6950
Shreveport, La. 8-1962
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P. O. BOX 9506 • OKLAHOMA CITY, OKLA.
EXPORT DISTRIBUTOR: THE NATIONAL SUPPLY CO., EXPORT DIVISION

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HOTEL PITTSBURGHER
Right in the heart of the Golden Triangle 400 outside rooms with TV and every comfort of modern hotel design. General Forbes Lounge and Dining Room . . . Air Conditioning. Airport Limousine and Taxi Service.
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JACKTOWN MOTOR HOTEL
The very finest accommodations. 60 air-conditioned rooms with TV, telephone, combination tile baths. Excellent dining room. Facilities for group parties 15 to 500.
Route 30
1 mile West of Irwin Interchange
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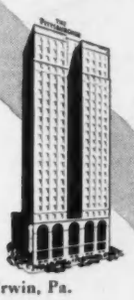

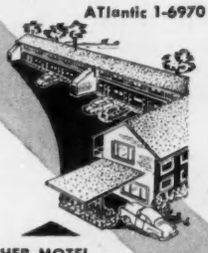

KNOTT HOTELS

Joseph F. Duddy, Gen. Mgr.

HOTEL PITTSBURGHER MOTEL
Opposite Greater Pittsburgh Airport on beautiful Airport Parkway West. 56 luxurious, air-conditioned rooms with tile bath, TV, private phone. Courtesy car to and from airport.
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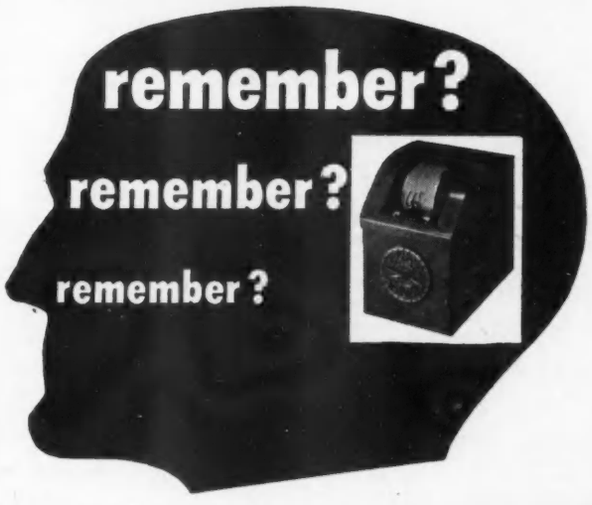

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in an advanced design particularly suitable for high pressures, elevated temperatures and other severe conditions.

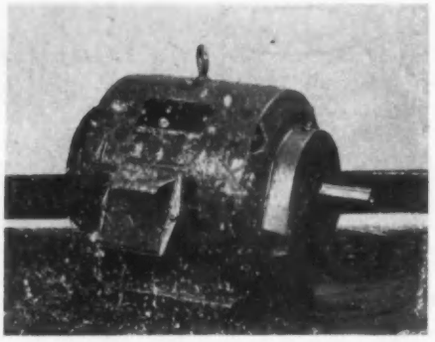
(This item supplements Rockwell Manufacturing Company, Nordstrom Valve Division, data on Pages 3805-3840 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E16** on Readers' Service Card, last page this issue.

Weatherproof AC Motor

A new weatherproof AC motor for use in outdoor type applications where the motor is subjected to extreme moisture or the elements is now available from Reliance Electric and Engineering Company in all standard speeds in sizes from 1 through 250 horsepower.

The new weather proof motor is engineered throughout to meet the punishment of adverse operating conditions. An open motor that exceeds NEMA splash-proof requirements, all of its external parts are of corrosion-proof cast iron. Shaft openings are sealed by a shaft cap and slinger.



The insulation system is completely non-hygroscopic. It features silicone sleeving, glass-mica slot liner and glass mat top-sticks and mid-sticks.

For more data, circle **No. E17** on Readers' Service Card, last page this issue.

Four-Way Valve

A new manually operated four-way valve, with built-in speed control, is announced by Valvair Corporation.

Designed to afford precise operating speed regulation of double acting cylinders and similar devices, in either or both directions, the new valve is offered with ¼ or ⅜-inch NPT ports. Large area control orifices are said to assure unrestricted flow when fully open, to permit precise adjustment of speed, and to provide exceptional freedom from clogging and restriction caused by impurities in the controlled fluid. Standard size hex head on flow control stem and hex lock nut facilitate accurate flow adjustment without the use of special tools.

For more data, circle **No. E18** on Readers' Service Card, last page this issue.

Motor Valve

Kimray, Inc., introduces a double acting motor valve, 125 psi WP, Series DA. Pressure may be applied to either or both sides of the diaphragm. The DA motor valve is spring-loaded to close against approximately 6 psi upstream pressure. The valve has single soft seat, full line opening, to insure tight shutoff.

Applications include oil metering vessels, oil and gas separators, low pressure (ounces) burner-manifold valves.

This DA series include valves from ¾-inch through 6-inch pipe sizes.

(This item supplements Kimray, Inc., data on Page 2845 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E19** on Readers' Service Card, last page this issue.

Tubing Bleed-Off

With safety of both personnel and the well in mind, Brown Oil Tools, Inc., recently has perfected the Brown tubing bleed-off assembly for pulling sanded-up or plugged tubing.

Pulling operations sometimes are unsafe because pressure is trapped between bridges in the tubing. The tubing bleed-off assembly minimizes the danger because control of the well and pressure and fluid in the tubing is maintained at all times.

The equipment basically is a pressure-tight mud-box with seals that hold in both directions. Outlets are provided between

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. . . oilmen say this new RB model is a superb example of modern, functional engineering design.

Fast, low-cost installation because it mounts on simple steel skid or flat concrete surface.

Its unique rack-and-pinion system enables one man standing on the ground to make counterweight adjustments easily, quickly and safely.

The New JENSEN RB brings profits up, keeps costs down. Get the facts on this all-new RB unit, as well as Jensen's famous beam balanced line of jacks.

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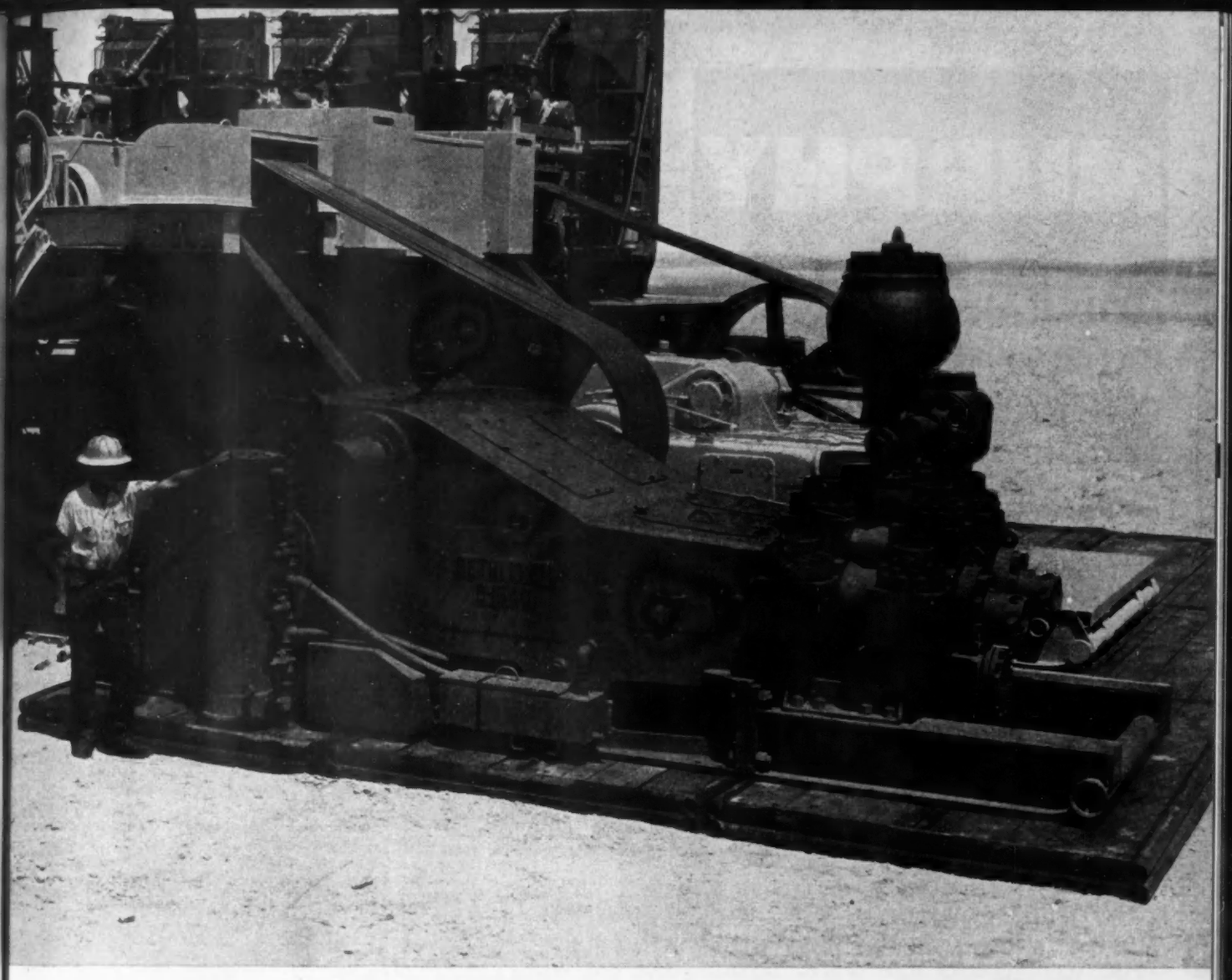
JENSEN JACKS



THE B-1640 *gets more horsepower to the bit than any other pump ever offered!*

Bethlehem's B-1640 is the first pump with enough horsepower to measurably increase rates of penetration in deepest drilling. This huge slush pump gets more actual horsepower to the *bit*—thereby speeding up drilling, and saving wear and tear on the bit itself.

The B-1640 eliminates the need for parallel or series operation. It is big enough—strong enough—to do the job alone. The fluid end is an assembly of interchangeable units made of forged steel. Suction and discharge manifolds are forged-steel fittings, stress-relieved and tested. The power-end frame is an all-steel weldment with double-side-plate construction. Gears and shafts are alloy-steel forgings. High-capacity roller bearings support all rotating loads.

In power, reserve, and economy of operation, the B-1640 leads the field. Call or write for complete information.

B-1640 Performance Data

Max volume (gpm) . . . Max pressure (psi) . . . Max input hp (ihp)
(Based on 100 pct volumetric and 85 pct mechanical efficiencies)

Liner sizes, in.		8	7½	7	6½	6
Vol. per crank rev., gal		12.59	10.91	9.33	7.86	6.50
Crank rpm						
50	gpm	630	546	467	393	325
	psi	2,570	2,920	3,360	3,900	4,570
	ihp	1,111	1,093	1,076	1,052	1,020
60	gpm	755	655	560	472	390
	psi	2,570	2,920	3,360	3,900	4,570
	ihp	1,333	1,312	1,291	1,262	1,223
70	gpm	881	764	653	550	455
	psi	2,570	2,920	3,360	3,900	4,570
	ihp	1,555	1,530	1,506	1,473	1,427
80	gpm	1,007	873	764	629	520
	psi	2,570	2,920	3,360	3,900	4,570
	ihp	1,777	1,749	1,722	1,683	1,631
90	gpm	1,133	982	840	707	585
	psi	2,570	2,920	3,360	3,900	4,570
	ihp	1,999	1,967	1,937	1,894	1,835

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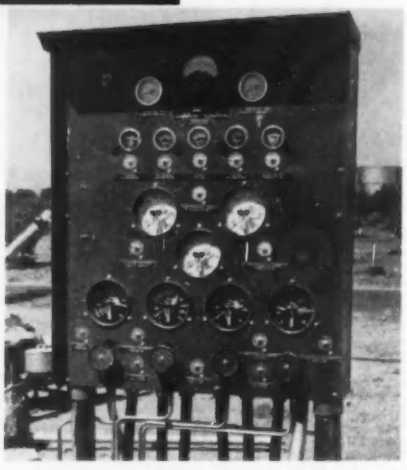
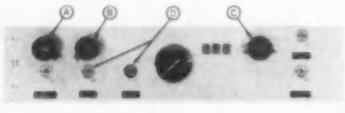
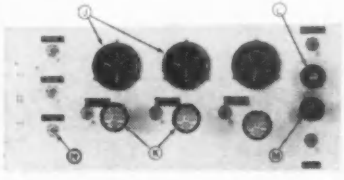


A Fillmore, California Installation



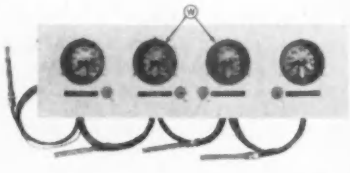
ENGINE CONTROL PANEL

Murphy Engine Safety Switches provide visible indication as well as positive shutdown in the event of trouble. A typical panel is equipped with (A) water temperature (SR-21), (B) oil pressure (0-75), (C) overspeed and overload (V-230), safety switches. In addition, individual Murphy "Tattletale" Switches (D) are installed to give indication of the cause of shutdown.



COMPRESSOR CONTROL PANEL

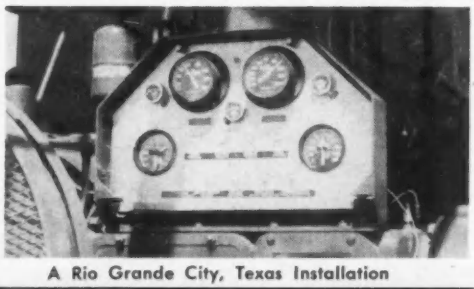
Complete compressor protection is afforded each function of your valuable equipment by this modular panel consisting of the following standard Murphy safety switches:
(J) OPL-F Hi-Lo Pressure Switches complete with (K) pulsation dampeners for suction, interstage and discharge pressures; (L) one compressor water jacket temperature (SR-21), (M) one compressor oil pressure (0-75), (N) one compressor oil level (L-100-W), and individual "Tattletale" Switches to show cause of shutdown. Saves valuable time in trouble-shooting.



COMPRESSOR TEMPERATURE CONTROL PANEL

These Murphy SPL Hi-Lo Temperature Safety Switches (W) will provide your compressor with precise temperature indication and protection throughout the system. Compressor operating conditions are most readily indicated by line temperatures and Murphy SPL units protect against excessive temperatures. Stainless steel seperable sockets permit easy installation.
Murphy "Tattletale" Switches pinpoint trouble automatically. SPL switches are available in these standard ranges: 100°-350°F, 260°-450°F, 30°-300°F. Other ranges on request.

Only Murphy Safety Switch offers complete compressor instrumentation providing indicating gauges with positive shutdown protection in standard or semi-standard panels with prices that S-T-R-E-T-C-H your equipment dollar.
Engine or electric-motor powered, your compressor can be Murphy-equipped through local dealer stocks of standard components or contact our Engineering Department for complete details.



A Rio Grande City, Texas Installation

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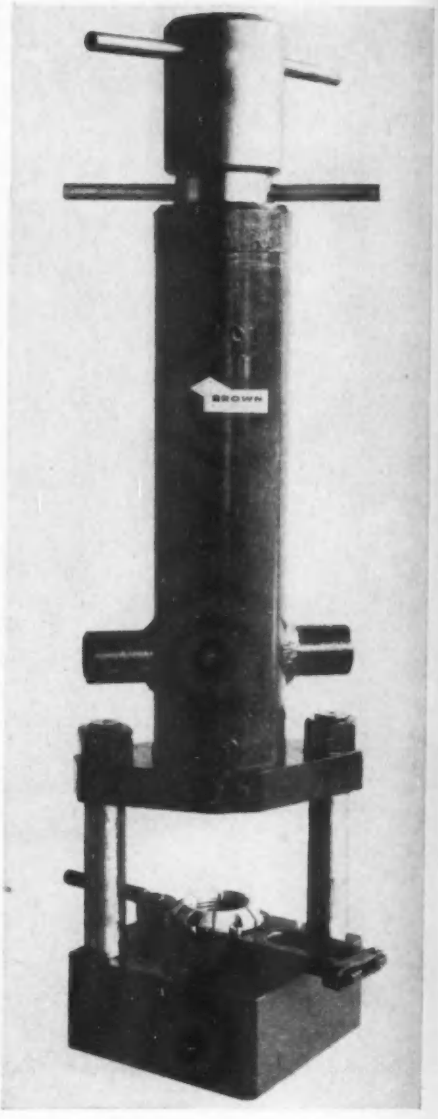
FRANK W. MURPHY *Manufacturer, Inc.*
RANCH ACRES STATION TULSA, OKLAHOMA



the seals to allow for controlled "Bleeding-off" of trapped pressure, and to allow for circulation back into the hole to kill the well.

(This item supplements Brown Oil Tools, Inc., data on Pages 871-873 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E20** on Readers' Service Card, last page this issue.

Non-Spiral Cutter

Beaver Pipe Tools, Inc., recently introduced a new non-spiral clear vue cutter to the market.

The new Beaver cutter has extra wide rollers to prevent spiraling. It cuts ⅛ to

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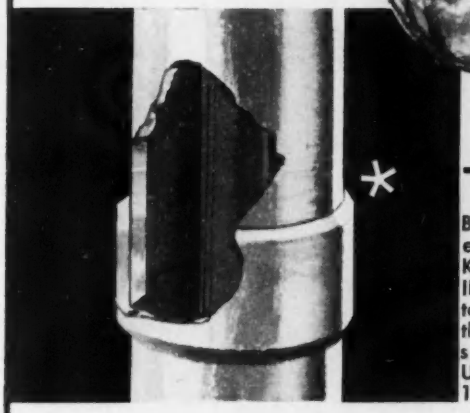

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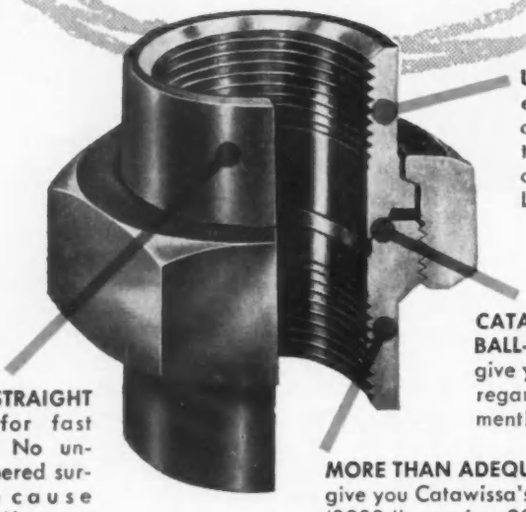

UNIFORM WALLS for even expansion and contraction under temperature changes. THEY FOLLOW THE PIPE!

CATAWISSA BALL-TO-ANGLE SEATS give you a "Perfect Seal" regardless of pipe alignment!

ROUND, STRAIGHT BARRELS for fast wrenching. No uneven or tapered surfaces to cause wrench slips or wrench locking!

MORE THAN ADEQUATE wall thicknesses give you Catawissa's 3-to-1 Safety Factor (3000-lb. service, 9000-lb. test; 6000-lb. service, 18000-lb. test)!

Catawissa Perfect Seal Pipe Unions are made by Union Specialists from 80,000-lb. tensile strength steel (ASTM Spec. A-105-55T, Grade II). Steel forgings from our own forging mill are closely checked for imperfections . . . and finishing on modern, automatic machines with close inspection during and after production give you pipe unions second to none!

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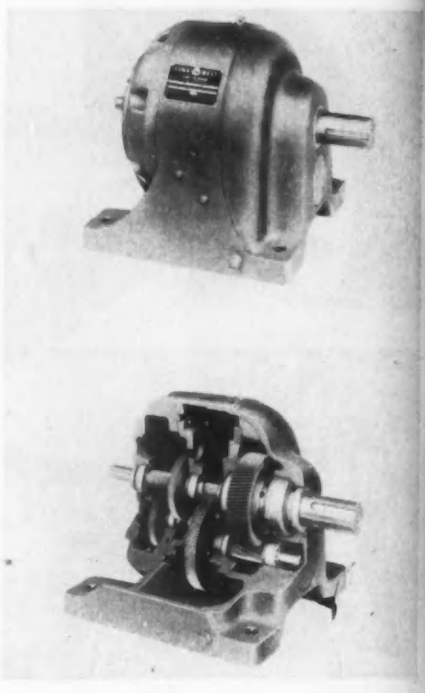
2-inch material. It is for hand or power drive use; thus one tool does the work for two tools. The position of the wheel gives the "clear view" that permits quick and accurate setting to mark. Fast and easy cuts are created because the pressure is applied directly to the cutter wheel for fast easy cutting.

(This item supplements Beaver Pipe Tools, Inc., data on Page 653 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E21** on Readers' Service Card, last page this issue.



Helical Gear Drives

Link-Belt Company now offers a quadruple reduction helical gear drive and new larger sizes of double and triple reduction drives to augment its present line of double and triple reduction in-line helical gear drives. Drives with capacities to more than 200 horsepower are available.

The extremely compact quadruple reduction speed reducer, available in five sizes, extends the range of ratios as high as 2,217:1.

The simple gear arrangement of these speed reducers consists of helical gear trains operating in high capacity ball and roller bearings mounted in a cast iron housing.

(This item supplements Link-Belt Co. data on Pages 3025-3064 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E22** on Readers' Service Card, last page this issue.

Bubble-Tight Plug Valve

The use-proven, non-lubricated Graham plug valve, incorporating the only advancement in plug valve design in many years, is now being manufactured and distributed by the Texsteam Corporation. The valve, with full-opening or round port, has many applications for the control of water, salt water, oil, gas, drilling fluids, cement, acid, air, fracture fluids, vacuums, etc.

Combining the non-lubrication feature and the Graham free-floating, self-aligning pressure sealing seats with the Texsteam

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Composite Catalog, Page 3419

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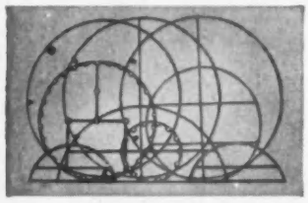

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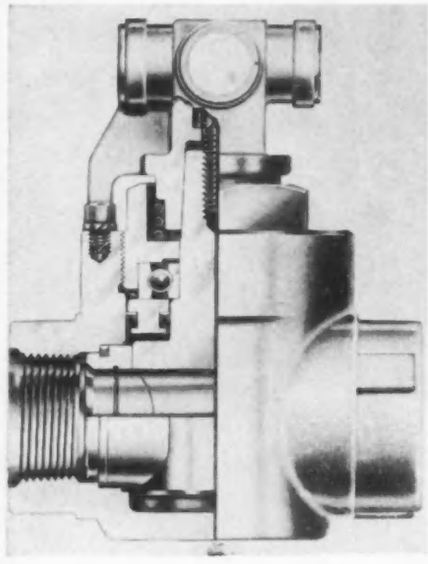
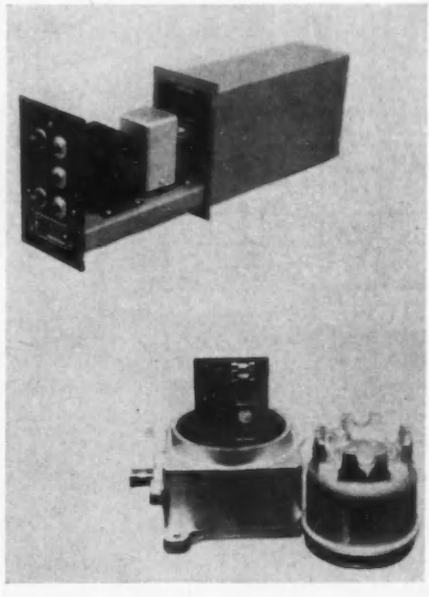


precision manufacturing and inspection procedures has produced a plug valve that meets the most exacting requirements of high pressure service with bubble-tight sealing, easy operation, quarter-turn opening and closing and low maintenance.

(This item supplements Texsteam Corporation data on Pages 5038-5043 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E23** on Readers' Service Card, last page this issue.



Model C-2 Controller

The Model C-2 controller available from Magnetic Industries, Inc., provides remote supervisory control of motor driven valves and pumps over a single pair of wires.

A typical valve control installation would provide controls for opening, closing and stopping the valve at an intermediate position with indications of valve full open, full closed and intermediate position.

No vacuum tubes are used. The circuitry is built on a plug-in unit basis for easy servicing. Hermetically sealed relays and quality components are used, making the equipment trouble free.

For more data, circle **No. E24** on Readers' Service Card, last page this issue.

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KINLEY SAND LINE CUTTER

M. M. Kinley Company, Licensees

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Assoc. Eng. & Eqpt., Inc. .... TE 5-7046, ZF 6-2023
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C. A. White 3-5284
GLENDIVE, MONTANA
C. A. White ..... EM 5-3833
HOBBS, NEW MEXICO
Horne Well Service Co. 3-5396
HOUSTON, TEXAS
Assoc. Eng. & Eqpt., Inc. ..... CA 5-1103
KILGORE, TEXAS
Davis-Kemp Tool Co., Inc. 5541
LAFAYETTE, LOUISIANA
Assoc. Eng. & Eqpt., Inc. ..... CE 5-6770
LIBERAL, KANSAS
Rainbo Service ..... Main 4-3598
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New Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Readers' Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card. Requests are transmitted to the manufacturer as soon as received by us for mailing of desired information directly to you.

Sucker Rod Chart

Axelson Manufacturing Company has recently made available a quick field reference guide for grade, yield and tensile strength of sucker rods. This new four-page Axelson brochure quickly and graphically compares the various makes of sucker rods in a condensed version suitable for carrying in a shirt pocket.

To get a copy, circle **No. E25** on Readers' Service Card, last page this issue.

Frigi-Gas Unit Folder

National Tank Company designed an improved method for handling high to moderate pressure distillate wells, particularly when flow rate requirements vary over a wide range of operations, i.e., rates from one tenth of a million per day up to rated recommended capacities, with ability to care for wide differences of throughput during the same 24-hour period. A colored flow diagram is available.

To get a copy, circle **No. E26** on Readers' Service Card, last page this issue.

Roller Chain Book

A comprehensive book on precision steel roller chains and sprockets, Book 2657, is available from Link-Belt Company and contains 154 pages of detailed engineering data illustrating roller chain's versatility in a wide range of applications.

Written to serve as a practical textbook on the use of roller chains for both power transmission and conveyor service, the book contains typical installation conditions, formulas, charts and diagrams to simplify selection of proper chains for any application.

To get a copy, circle **No. E27** on Readers' Service Card, last page this issue.

Flow Meter Book

The publication of the eighth edition of "Principles and Practice of Flow Meter Engineering" by L. K. Spink has been announced by The Foxboro Company. Added are the latest developments in flow measurement, making the new text the largest, most complete and authoritative book to be published on flow meter engineering.

To get a copy, circle **No. E28** on Readers' Service Card, last page this issue.

Packer Brochure

The Guiberson Corporation, one of the Dresser Industries, announces availability of a four-page color bulletin illustrating and describing the new Guiberson Shorty-Tension packer. The Shorty-Tension packer is an exceptionally short packer designed for use in water-flooding, acidizing, fracturing and other below-packer pressure applications. Simple, rugged construction makes redressing an extremely easy operation and assures positive setting —quick release.

To get a copy, circle **No. E29** on Readers' Service Card, last page this issue.

Hydraulic Pump Booklet

An increase in the cycle rate of Axelson's 4-foot Hydrax hydraulic pumping unit provides a much more versatile unit for varying field production requirements. The unit, manufactured by the Axelson Manufacturing Company, a division of U. S. Industries, Inc., has been modified to allow an extended cycle rate from 6 to 9 cycles per minute. This design provides high volume production at minimum cost to the operator without destroying the inherent advantages of hydraulic pumping.

To get a copy, circle **No. E30** on Readers' Service Card, last page this issue.

Filter Replacement Tips

Helpful service tips on filter replacement are given in "Not an Element of Doubt," an eight-page booklet released by Caterpillar Tractor Co.

Filtering improvements developed by Caterpillar are explained in detail. The two-color booklet contains cost study information coupled with recommendations for extending oil change periods. Cutaway photographs show the inner parts of filter elements and point out their design characteristics. The importance of proper fit, temperature stability and rate of oil flow are also discussed.

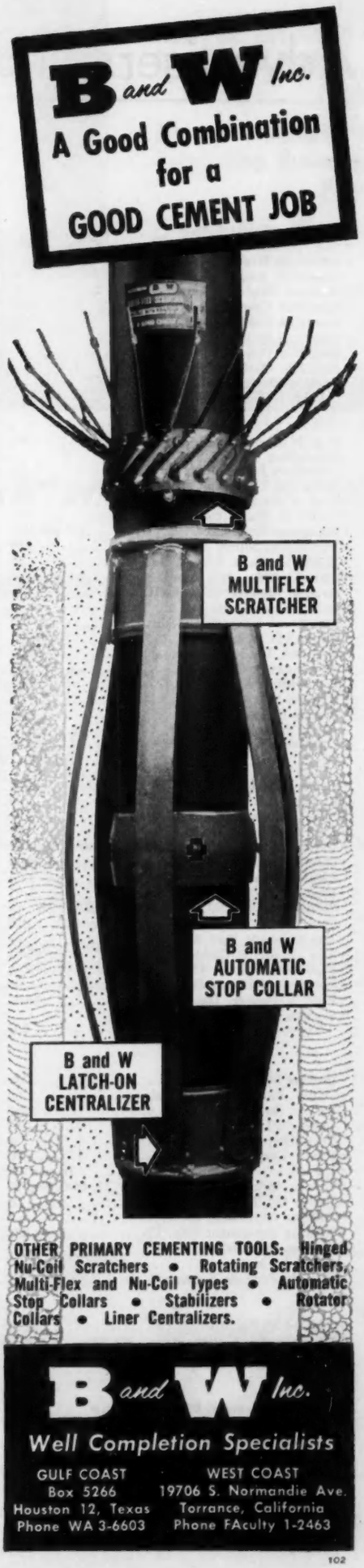
To get a copy, circle **No. E31** on Readers' Service Card, last page this issue.

Mixco Lab Booklet

A six-page folder describing the complete laboratory facilities now available to the industry at Mixing Equipment Company, is available. A special section is devoted to the new hazardous materials laboratory.

The folder outlines the pilot-plant mixing operations of the hazardous materials laboratory and describes the unique uses of the new continuous multi-stage contractor.

To get a copy, circle **No. E32** on Readers' Service Card, last page this issue.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